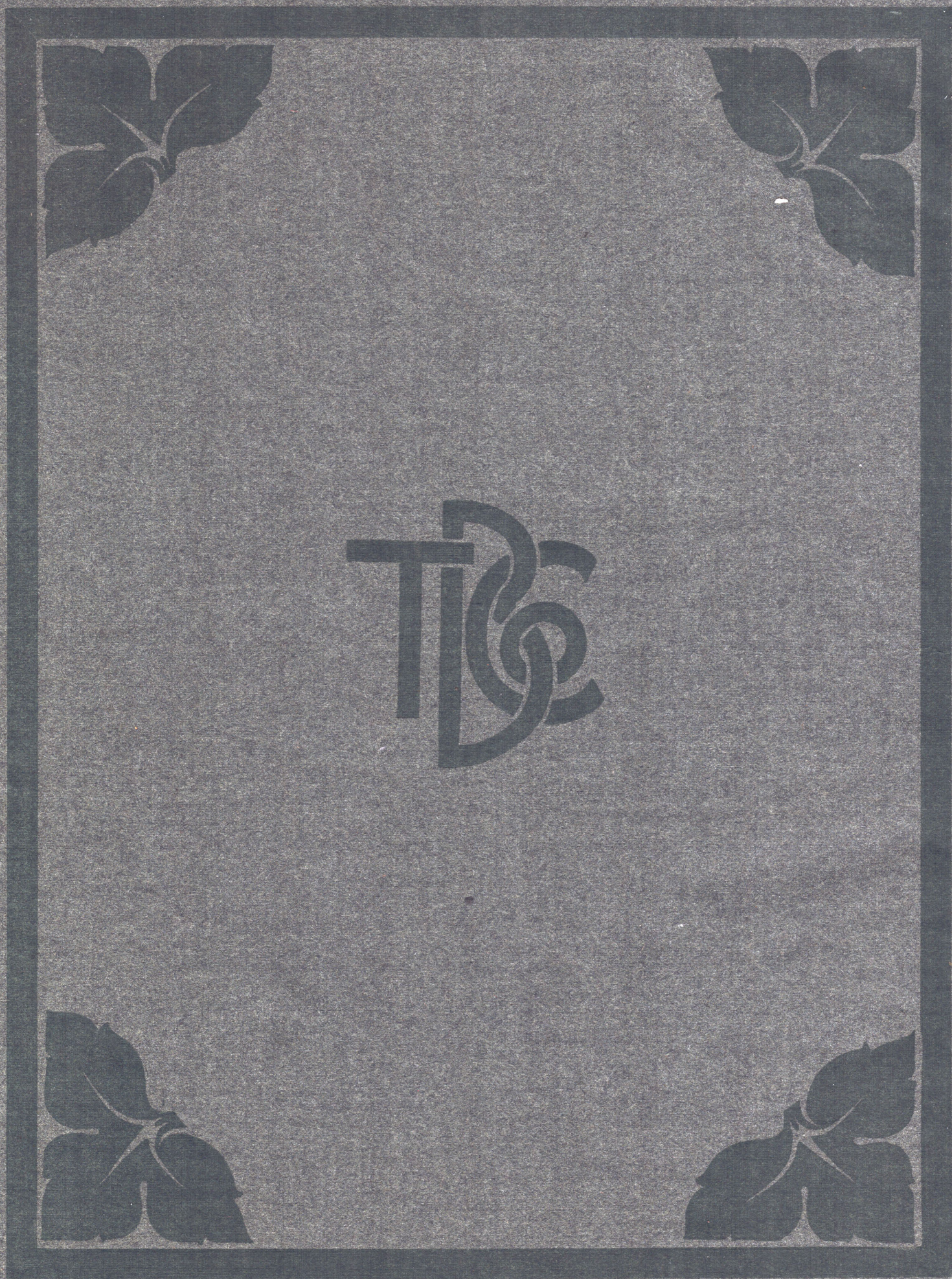


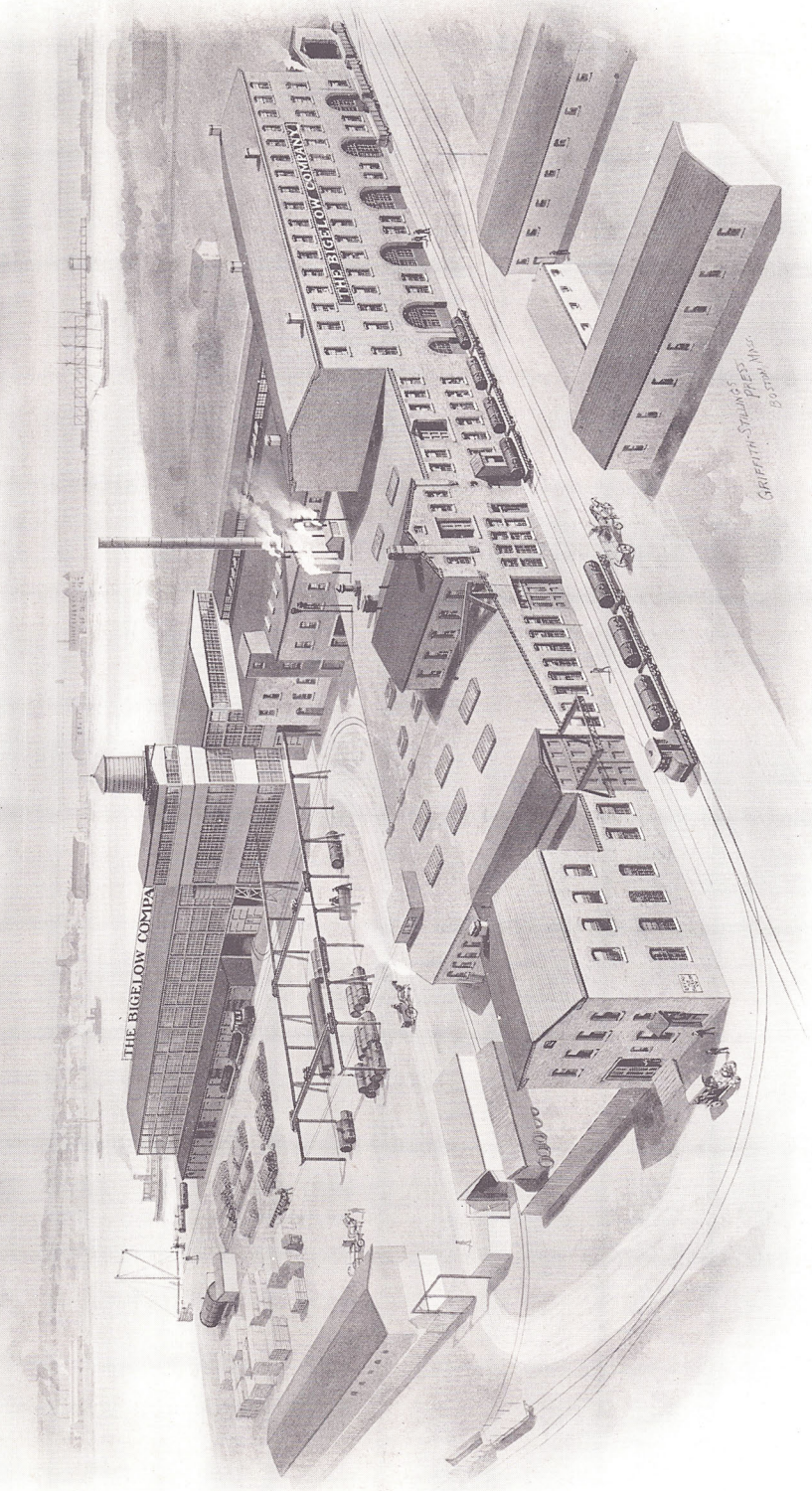
BIGELOW FIRE TUBE BOILERS



THE BIGELOW COMPANY
NEW HAVEN, CONN., U.S.A.



J. W. Crowley
449 main st. st. j. n. B



GRIFFITH-STOLING'S
PRESS, N.Y.
805TH

WORKS OF THE BIGELOW COMPANY, NEW HAVEN, CONN., U.S.A.

The Bigelow Company

ESTABLISHED 1860

MANUFACTURERS OF

STEAM BOILERS

Stacks, Flues, Dryers, Coolers
Digesters, Vulcanizers
Jacketed Tanks, Plate Iron Work
and Heavy Special Machinery



This Catalog covers the above. We are also manufacturers of the Bigelow-Hornsby
Water Tube Boiler, and will send catalog on request

F. L. BIGELOW		President
G. S. BARNUM		Vice-President
S. H. BARNUM, 2d		Secretary

1912

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By THE BIGELOW COMPANY
New Haven, Conn.

Introduction



THE many improvements which we have made in boiler construction, the growth of our plant necessary to keep pace with the continual increase in business, and the number of new and interesting features of Bigelow Horizontal Return Tubular Boilers and Bigelow Manning and Straight Shell Upright Boilers justify us issuing a new catalog at this time.

The annual increase in our volume of business has enabled us to command the very highest type of professional and mechanical service. We maintain such a high standard of efficiency that we believe our facilities for boiler construction to be without a parallel in this country.

We call your attention to the bird's-eye view, which will give you a general idea of the extent of our plant.

Attention is directed to the departments dealing with Horizontal Return Tubular Boilers, Manning Boilers, Locomotive Boilers and Internally Fired Boilers, Pressure Tanks, Vulcanizers, Lard Coolers, Digesters and Cupolas.

We are thoroughly equipped to design and construct ammonia condensers, chemical vessels, special cooking and drying apparatus for rendering plants and slaughterhouses, also heavy machinery of all kinds.

In this catalog we have endeavored to outline a clear and concise statement of all facts tending to promote a complete understanding of our methods of construction, and to enumerate the factors conducive to successful installation of boilers.

Our purpose has been to present technical information in such manner as to be of value to engineers and easily understood by the laymen, and to establish logical sequence of the data in order to facilitate easy reference.

A glance at the index, page 72, will give you a speedy reference to any specific information you may desire.

THE BIGELOW COMPANY.

Horizontal Return Tubular Boilers



WHILE the general features of both operation and construction of the Horizontal Return Tubular Boiler are better understood by the American engineer than those of any other type, they will bear repetition here, on account of their superiority.

The Horizontal Return Tubular Boiler was the logical outcome of the effort to perfect the Horizontal Flue Boiler, and while it retains the

Simplicity

many good features of this type, it has in addition the very necessary features of compactness and efficiency, so that it fills all the requirements of a modern steam generator. It would be hard to conceive a more simple or effective construction than the arrangement of this type of boiler. A cylindrical shell closed at each end provides the space to contain the necessary water and steam. The water space contains a large number of tubes so as to present a large surface for the absorption of heat from the products of combustion, and also to divide the heated gases into small streams, so that they may readily impart their heat to the water.

Erection and Setting

This type of boiler is strictly self-contained; there are no parts to be fitted or adjusted after it has been delivered to the purchaser. If it is of the lug-supported type it is only necessary to block it up in the desired location with the front in place and build the setting around it. The setting acts as the support for the boiler and also forms the furnace and the combustion chamber. If the hung type of boiler is used (Plate 3) the erection is further simplified, for in this case the boiler is carried on the supporting columns, and the setting is used alone to form the furnace and to confine the products of combustion so that their heat will be efficiently transmitted to the contained water. While the above describes the general arrangement used for hand-fired grates, the Horizontal Return Tubular Boiler can be readily arranged for use with any type of extension furnace (see Plate 4) or stoker. (Further detail as to the erection and setting is described in article on page 14.)

Direct Heating Surface

That this boiler can be forced to meet the demand for heavy overload required in modern power-house operation, is due to the fact that a relatively large portion of its heating surface is direct heating surface. About ten per cent of the total heating surface in this type is contained in the shell. This is a much larger percentage of direct heating surface than is contained in the average boiler.

Easy Cleaning

With this type of boiler arranged with a manhole below the tubes (which is the method of construction we recommend for all sizes over fifty-four inches in diameter), the ease with which the heating surface, both externally and internally, can be reached for cleaning is evident. Keeping the heating surface clean is the most important point in boiler operation, contributing to high working efficiency, and by having a boiler that can be easily cleaned the desired end is half accomplished.

Large Liberating Surface

The necessity for large liberating surface to permit the disengagement of the steam without entraining the water is a point the value of which is well recognized by every engineer. The Horizontal Return Tubular Boiler has more liberating surface than practically any other modern type, and on this account it gives very dry steam when properly designed, so that sufficient steam space is provided.

Circulation

Our design of the Horizontal Return Tubular Boiler provides a wide, vertical center aisle between the tubes and ample space from the tubes to the shell on the sides, which insures perfect circulation of the water.

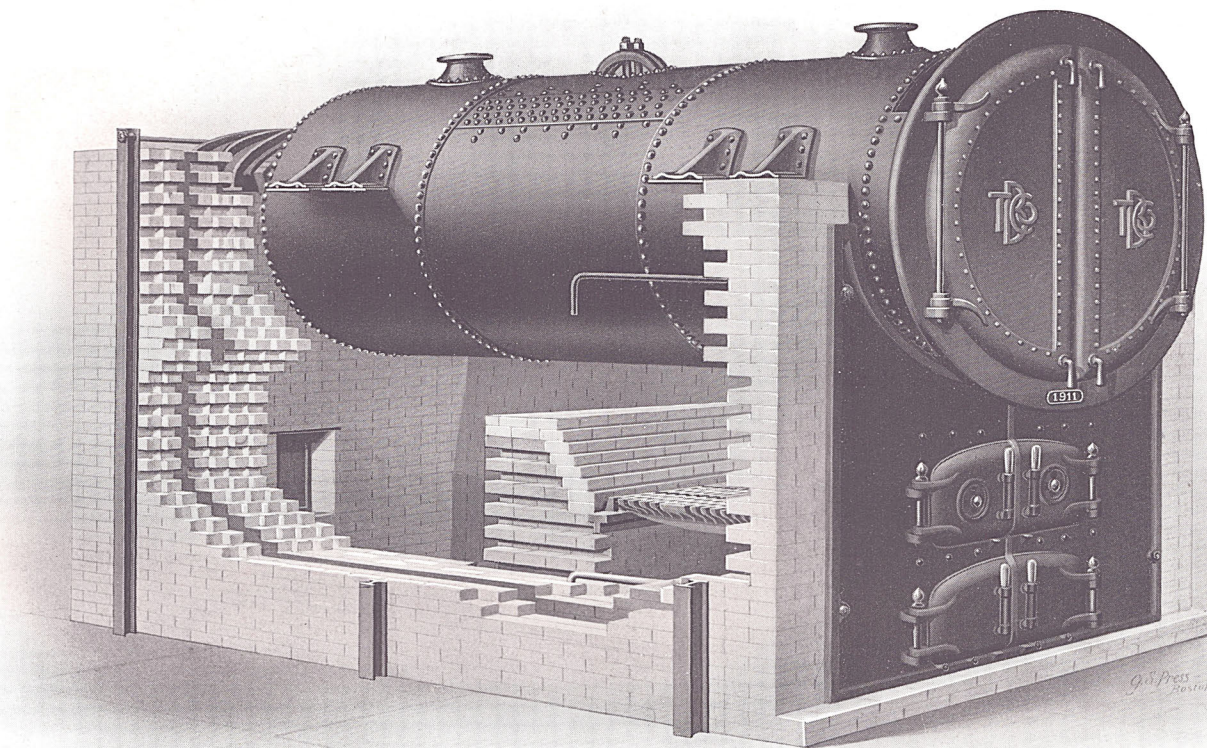


PLATE 1

Illustrating Horizontal Return Tubular Boiler set with overhanging cast-iron front

While this type of boiler, when well constructed, is less liable to require repair than any other type, when repairs are necessary they can be made in the most simple manner. If the removal of a tube is required, both ends may be readily reached for cutting out the old and expanding in the new. The riveted seams are arranged so they are all accessible for inspection and repairs.

Repairs

The horizontal seams are entirely removed from contact with the flame or heated gases. The girth seams, where tightness is the important factor, are made single riveted and are, therefore, thoroughly capable of resisting the furnace temperatures. Our hydraulic riveting equipment permits the instant application of any one of six different pressures, permitting each diameter of rivet being driven with the pressure best suited to its size and thickness of plates joined, insuring all riveted joints being mechanically perfect. Our designs for longitudinal riveted joints give the maximum strength that can be obtained in riveted joints that are practical for boiler construction.

Riveted Joints

We have been the leaders in the application of pressed steel work to boiler construction. (See Plate 32.) Cast iron has been entirely eliminated from the construction of the boiler proper, and all nozzles and other attachments are made of the same quality of material as used in the shell and heads, so that the greatest safety and strength are assured by permitting such attachments to be riveted on the shell by hydraulic pressure, which is a very important point.

Nozzles

For supporting our hung type of boilers we use our special design of pressed steel hanger pad (see Plate 32), which is arranged so that the supported load is distributed to all the rivets that attach it to the shell, preventing the concentration of this load

**Hanger Pads
and Brackets**

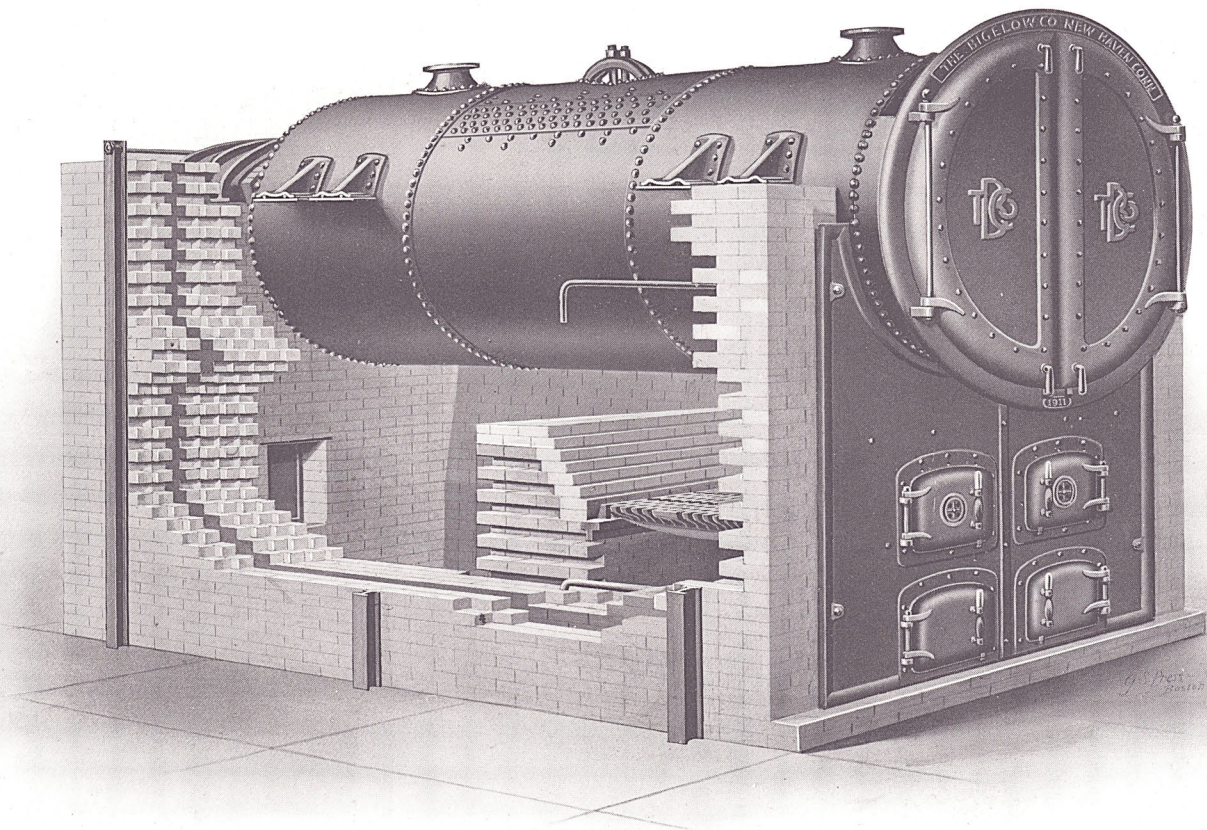


PLATE 2

Illustrating Horizontal Return Tubular Boiler set with overhanging plate steel front

on the shell at one point. For our lug-supported boilers we use the most modern type of pressed steel bracket, manufactured by ourselves. (See Plate 32.)

**Manhole
Re-enforcements**

We manufacture our own pressed steel manhole re-enforcements, which are designed to meet the most exacting requirements for the re-enforcement of such openings. (See Plate 32.) The arrangement of rivets is such that the maximum strength in both rivets and plate is secured.

Feed Connection

The feed connection is located in the head or shell as may be desired by the purchaser. This connection is made with a special internally and externally threaded steel or brass bushing, insuring tightness under all conditions of operation.

Fronts

We were the originators in the adaptation of sectional plate steel to the manufacture of boiler fronts, and while we have had many imitators it is only necessary to view a Bigelow boiler front to be convinced of its superiority. The sectional method of construction used, absolutely prevents any tendency towards cracking, and the heavy pattern cast-iron door frames and channels prevent warping. Our fronts are made in both the Flush and Overhanging patterns, and with single or double door openings as customers may desire. (See pages 14 and 15 for illustrations of the different types of fronts.)

Binder Bars

Where binder bars are required, we furnish standard six-inch steel "I" beam sections, for this is the strongest and stiffest section per pound of material that is suitable for the purpose. We also have patterns for a variety of sections for cast-iron binder bars where these are desired.

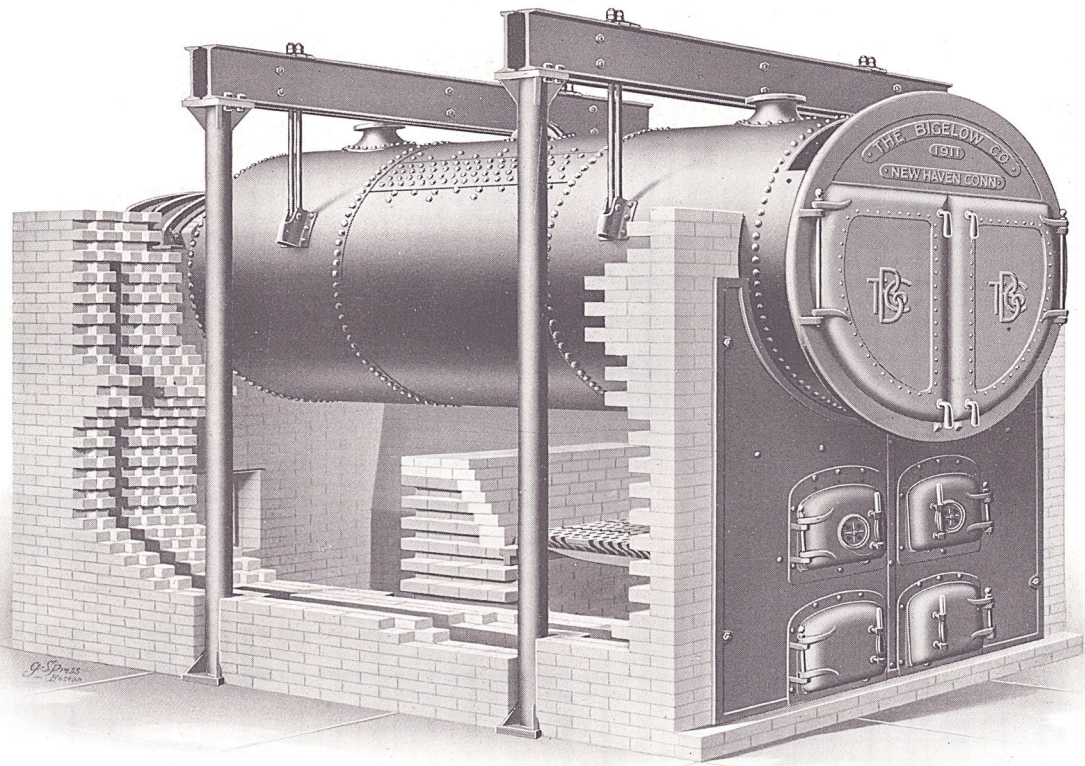


PLATE 3

Illustrating Horizontal Return Tubular Boiler suspended from I Beams resting on columns, with overhanging plate steel front

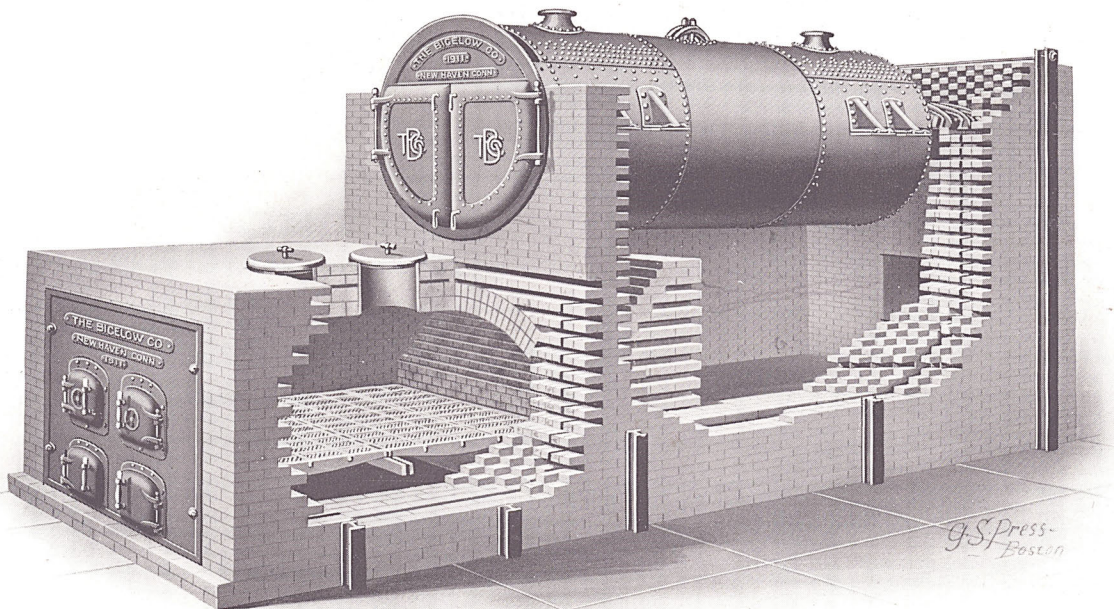


PLATE 4

Illustrating Horizontal Return Tubular Boiler set with Dutch oven and plate steel front

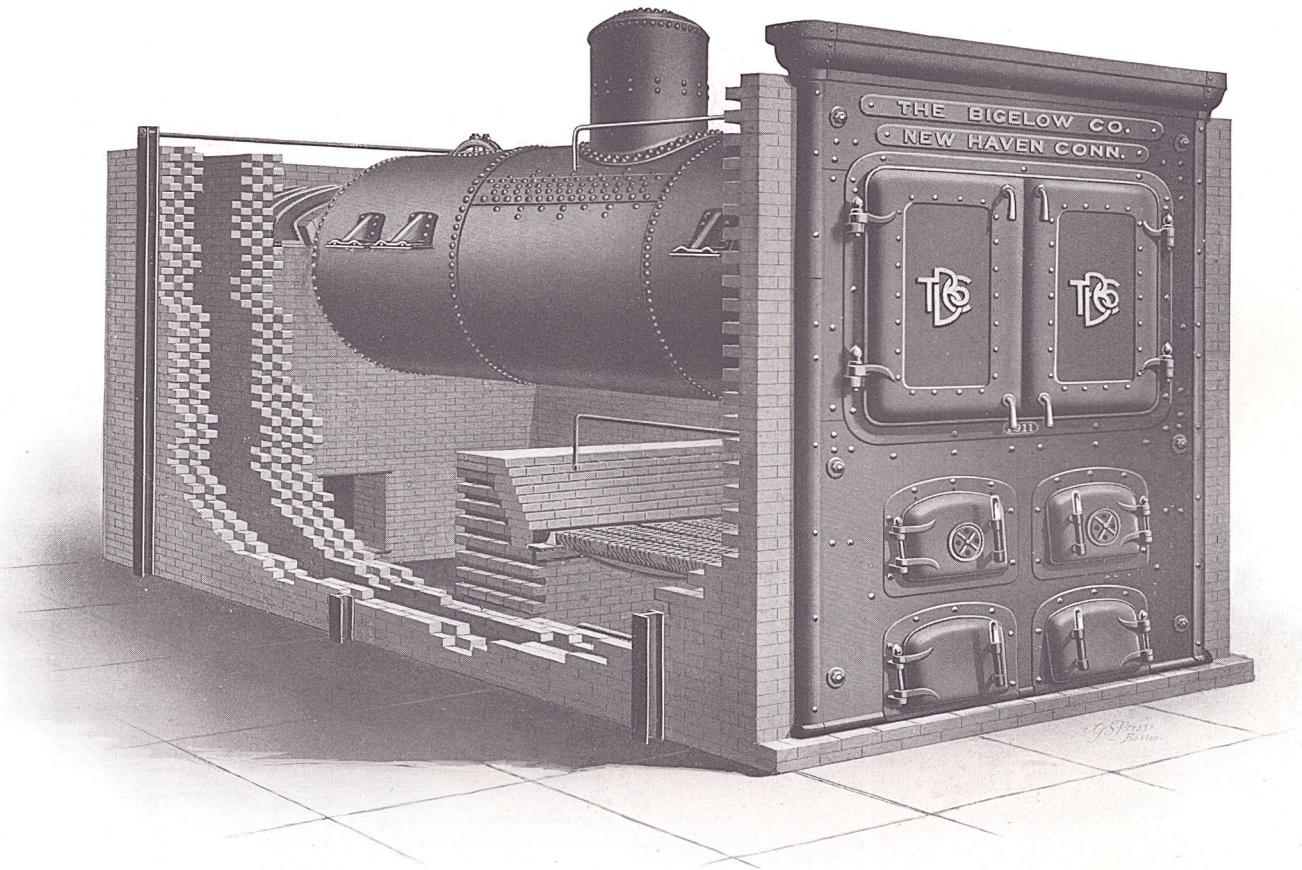


PLATE 5

Illustrating Horizontal Return Tubular Boiler set with plate steel flush front

Arch Bars

We furnish a very heavy pattern cast-iron arch bar for covering the back connection, arranged to receive standard sized fire-brick for lining. The lining thoroughly protects these bars from the heat and they last indefinitely. (Plate 25 illustrates their construction.)

Linings for Fire Door Openings

We are prepared to furnish cast-iron cheek pieces and arches with inner removable cheek pieces and arches, arranged so that these parts may be removed when burned out without disturbing the brickwork. (See Plate 6.) We also furnish specially designed arch and cheek pieces made of fire clay for this purpose. (See Plate 8.)

Cleanout Doors

Our cleanout doors and frames are made of heavy pattern so as to resist any tendency to warp. The doors are closely fitted to the frames, preventing any leakage of air into the setting at these openings. (See Plate 21.)

Grates

We furnish three types of bars for stationary grates—Rowley, Herringbone and Maitland—all illustrated (Plate 33). Our patterns for the Maitland and Herringbone types of bars give a wide range of air spacing between the bars, permitting the selection

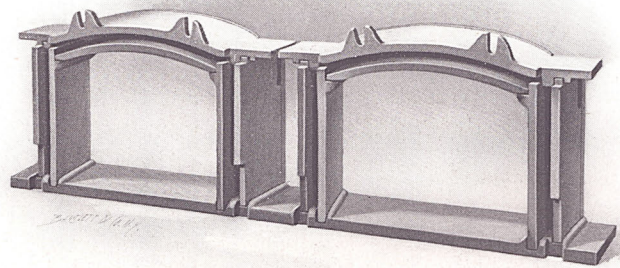


PLATE 6

Illustrating cast-iron removable type of arch and jamb

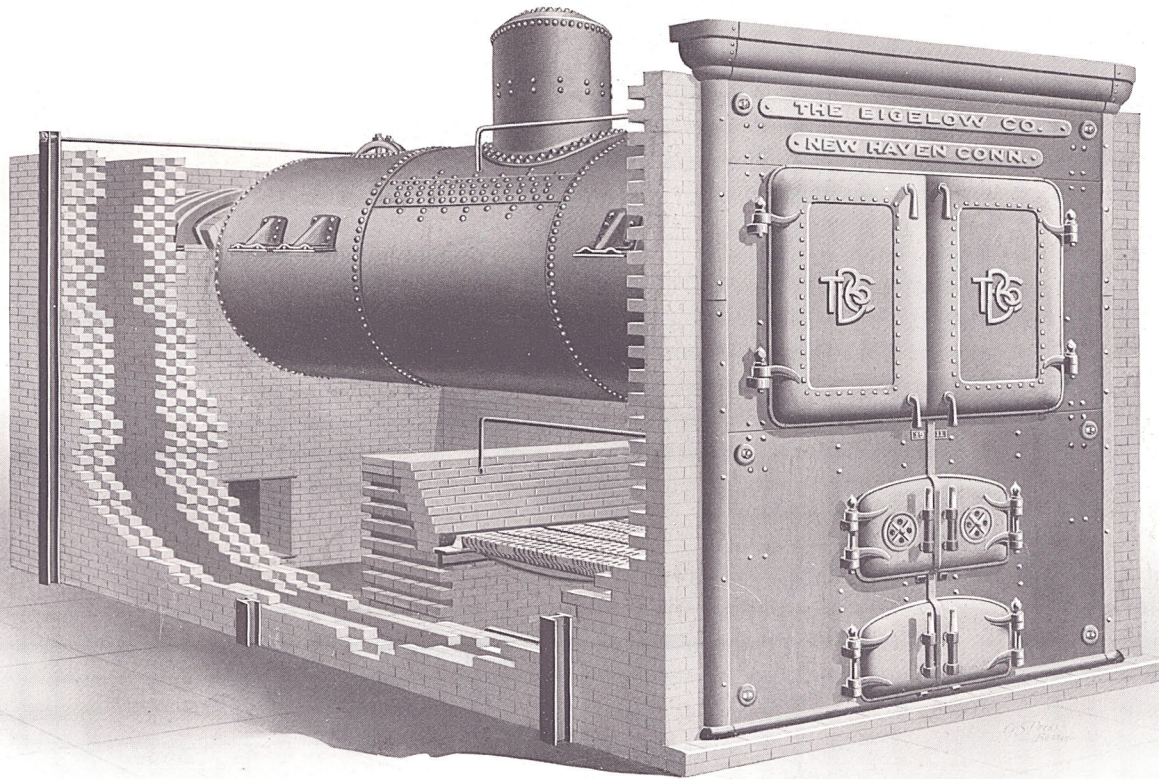


PLATE 7

Illustrating Horizontal Return Tubular Boiler set with cast-iron flush front

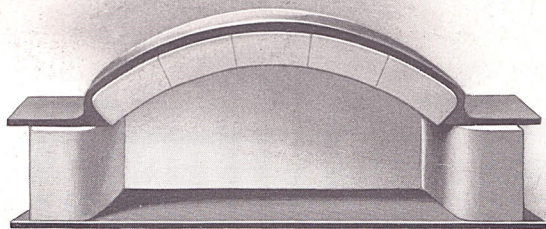


PLATE 8

Illustrating fire-brick arch and jamb

of the best width of opening to suit any particular grade of fuel. In addition to our complete line of stationary grates, we are prepared to submit figures covering any type of shaking grate on the market.

Our standard water column (see Plate 23) is of very heavy pattern and is suitable for any boiler pressure. We are also prepared to equip boilers with automatic high and low water alarm columns where this type is desired.

We are prepared to furnish any of

Water Column

**Safety Valves and
Steam Gauges**

the standard makes of safety valves or steam gauges or other trimmings on the market. When the selection of the trimmings is left to our judgment by the purchaser, a high quality only is furnished.

Where desired we are prepared to furnish complete specifications and setting plans for this type of boiler. We flange all our own tube sheets and manufacture the various attachments from tested stock, in order that our product may contain only material of known quality and of the highest grade.

Specifications

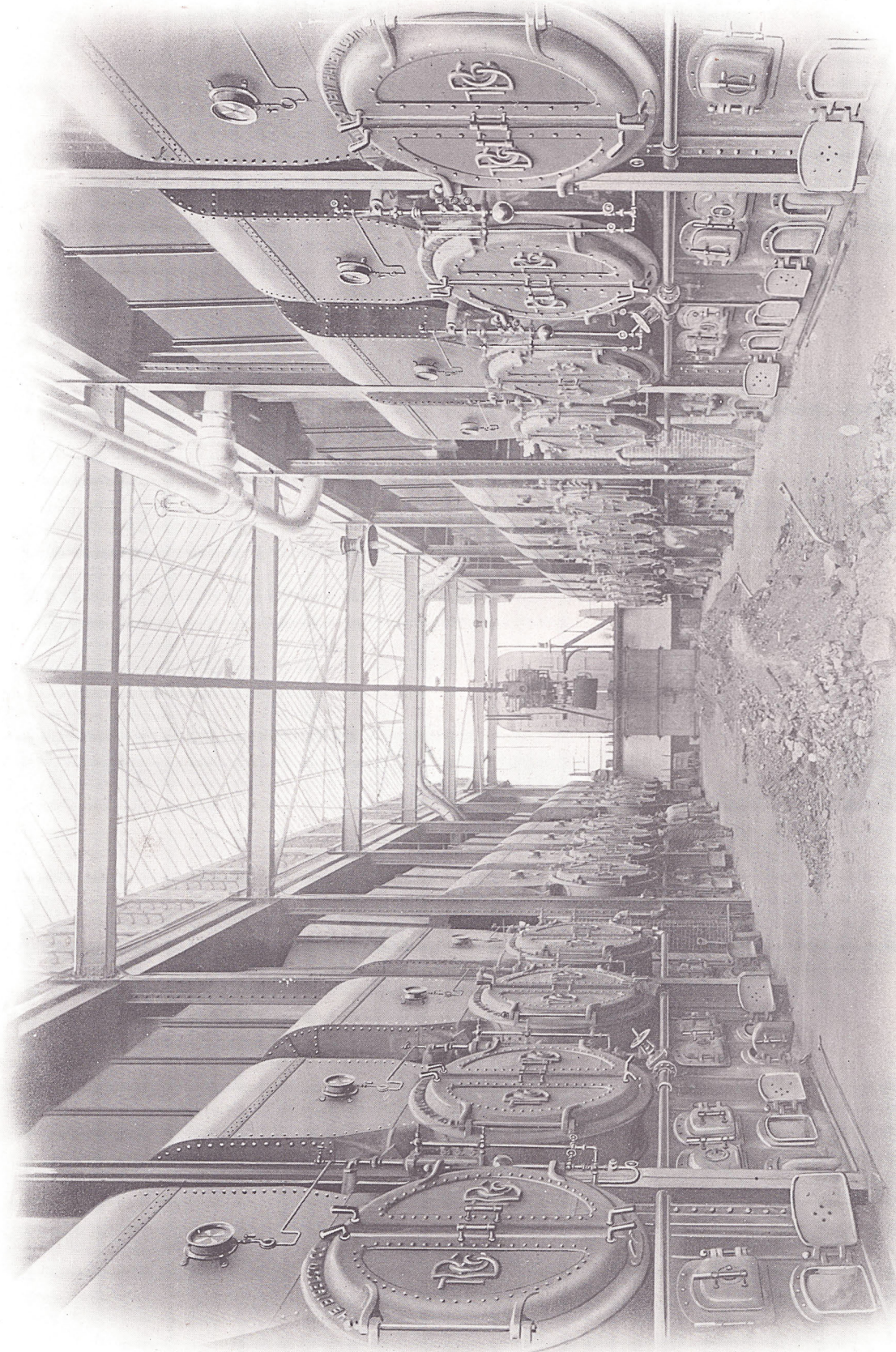


PLATE 9

Illustrating battery of Horizontal Return Tubular Boilers with overhanging fronts, installed at the Pacific Mills, Lawrence, Mass.

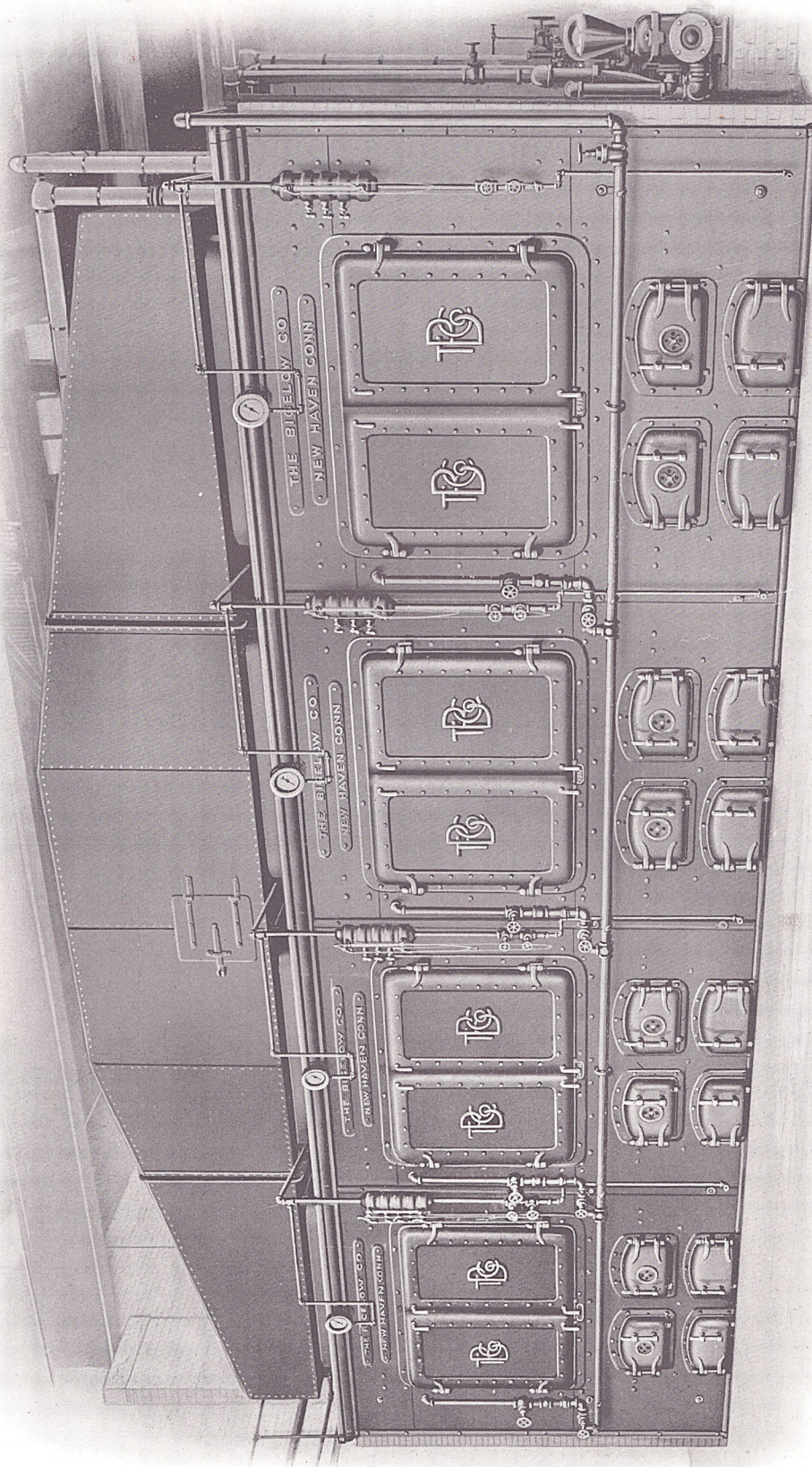


PLATE 10
Illustrating battery of Horizontal Return Tubular Boilers with flush fronts

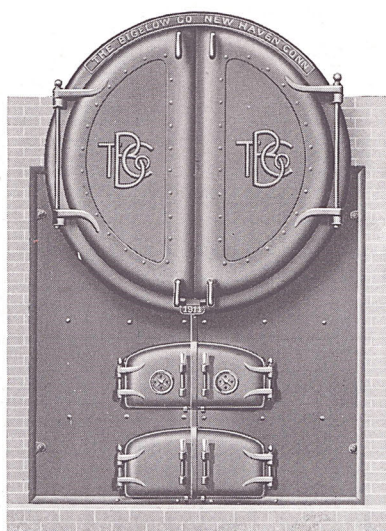


PLATE 11
Illustrating overhanging cast-iron front with single fire door opening and full flue doors

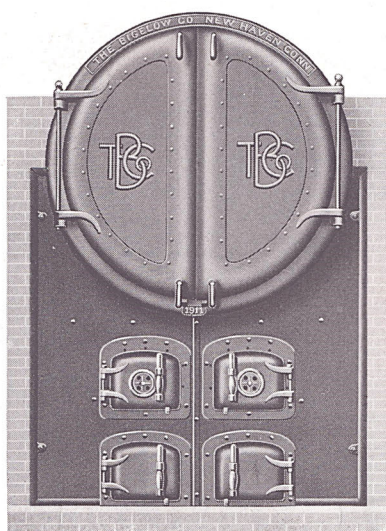


PLATE 12
Illustrating overhanging plate steel front with two fire door openings and full flue doors

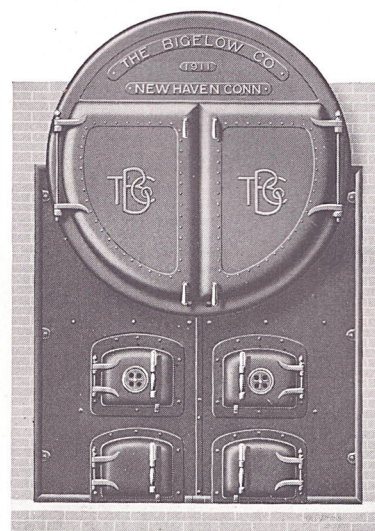


PLATE 13
Illustrating overhanging plate steel front with two fire door openings and half flue doors

Setting Horizontal Return Tubular Boilers

Foundations

The first thing necessary to secure a setting that will remain tight and free from cracking is a good foundation. This should be prepared before the arrival of the boiler. We will furnish setting plans giving the dimensions of the setting walls, and from this the proper dimensions and location of the foundation walls may be obtained.

Unloading

When a boiler arrives it should be carefully unloaded and transported to the site of erection. One should remember that it is made up of a number of plates riveted together, and that the tightness of each tube depends upon two expanded joints; therefore a boiler should be handled with care. Pipes or bars should never be stuck in the tubes to aid in moving the boiler.

Placing the Boiler in Position

Place the boiler in the correct position with the front properly set up before commencing the brickwork. When a boiler is to be supported on lugs resting on the brickwork, place it half an inch higher than the desired final position, to allow for lowering on the brickwork when the supports are removed. If a boiler is to be hung from beams it can be placed in the correct position at once. No weight should be carried by the boiler front. To insure against this leave three-eighths to one-half inch clearance between the bottom of the shell and the front. This is especially important in the lug-supported type in order to allow for settling.

The front end of a boiler should be set one inch higher than the rear to aid in draining through the blow-off pipe when washing out. This also allows an extra inch depth of water over the rear tube ends, a precaution against damage from low water. In leveling a boiler crosswise consider two points, the top line of tubes and the face of the steam nozzle.

Temporary Support

Barrels are preferable to blocking for supporting a boiler while the setting walls are being built, for they are less in the way of the masons. Two heavy oil barrels will support a sixty-six-inch by sixteen-foot boiler, if the blocking below them and on top is arranged so that the load is distributed evenly over all the staves. Use more barrels

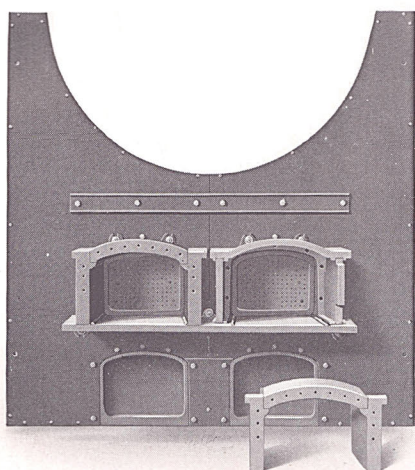


PLATE 14

Illustrating back of plate steel overhanging front with the arrangement of arch and jamb in place and removed

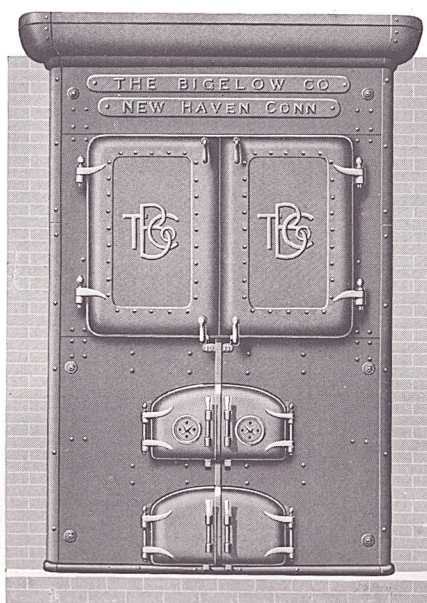


PLATE 15

Illustrating cast-iron flush front with single fire door opening

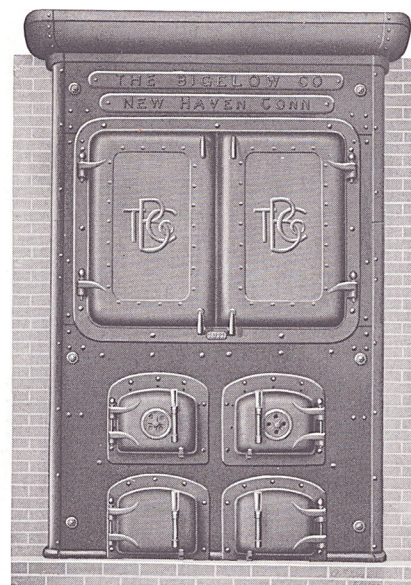


PLATE 16

Illustrating plate steel flush front with two fire door openings

for larger boilers and arrange the blocking on top so that the load will be distributed evenly between the barrels. If good barrels are not available, a cribwork of blocks placed under the front and rear of the shell will serve the purpose. Care should be used in the arrangement of the blocking so that it will not interfere with the building of the setting walls.

Some masons use common lime mortar in building boiler settings, but a much better and more lasting job can be obtained by adding cement to the bonding mixture. First mix regular lime mortar, using three-quarters of a cubic yard of good, sharp sand to one barrel of lime. Then make a mixture of sand and cement, using two barrels of sand to one barrel or four bags of cement; add this to the lime mortar and then it is ready for use, and this quantity should be enough to lay about a thousand bricks. If all the mortar cannot be used at once, the sand and cement mixture should be added only to such portion of the lime mortar as will be required for immediate use. It is difficult to keep it in proper condition for use overnight after the cement has been added. Fire-clay only should be used for bonding, in laying fire-brick. For this purpose mix it with water to about the consistency of butter-milk, so that the bricks may be dipped in it and rubbed together when laying them. About two barrels of fire-clay are required to lay one thousand bricks.

**Materials
Required**

To estimate the amount of common bricks required for a boiler setting, figure the number of cubic feet of wall to be laid with this kind of brick, and multiply by twenty-three; the result will be the number of bricks required. In making calculations no deductions should be made for openings in the setting walls for cleaning doors, etc.; the waste from breakage and cutting will require the extra brick figured in this way. Where fire lining is laid four and one-half inches thick and with every sixth course a header, figure eight fire-bricks for each square foot of wall surface lined in this manner. If the lining is to be nine inches thick and with every sixth

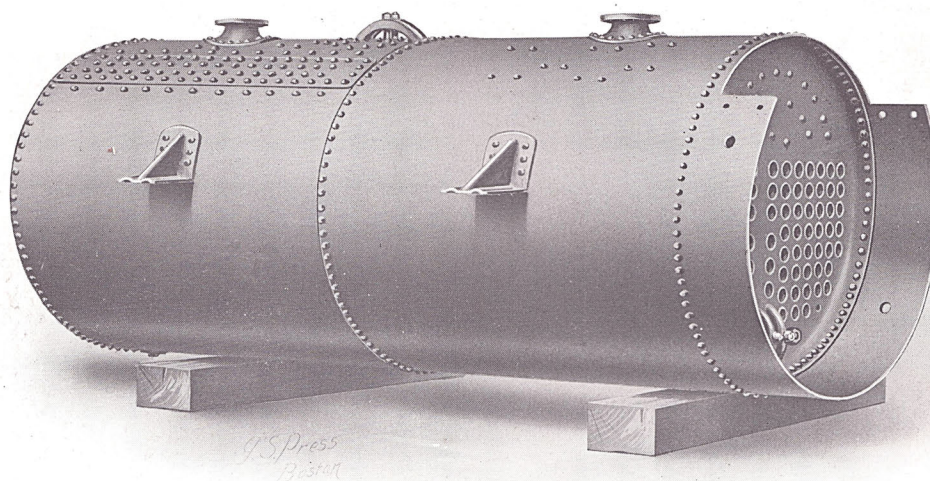


PLATE 17

Illustrating Horizontal Return Tubular Boiler made in two courses with triple riveted butt joint and two pressed steel brackets on each side

course tied to the common brick with a header, figure in fifteen bricks for every square foot of wall surface lined.

Return tubular boilers are set with an air-spaced wall. This lessens the radiation losses by keeping down the temperature of the exposed wall surface. The chief advantage of the air-space construction, however, is that when properly built it tends to prevent the cracking of the outer wall surface and therefore makes a better-looking setting. An important point in the designing of setting walls, to prevent cracking, is the method used to join the ends of the bridge wall with the side walls. Usually a mason will build the two at the same time and tie the bridge wall rigidly to the side walls. This will result in cracked side walls, because the bridge wall expands when heated and pushes out the side walls. With the wall having an air space this does not necessarily show on the outer wall unless the two are tied together at this point.

There are two ways of preventing trouble from expansion of the bridge wall, one by leaving the ends of the bridge wall about an inch away from the side walls, packing the space with asbestos or mineral wool. The elasticity of the packing allows for the expansion of the bridge wall and it prevents the space from becoming clogged with ashes and cinders. The other way is to build a recess about four and one half inches deep in the side walls having the same shape as a vertical section of the bridge wall, and build the ends of the bridge wall into this recess, leaving one and one-half inches of clearance at each end for expansion. (See cut, page 28.)

The chief function of a bridge wall is to limit the length of grate surface by presenting a barrier beyond which the spreading of the fuel is prevented; it also aids in mingling the unburned gases and air, so as to cause complete combustion before reaching the tubes. Where girth seams are located in the vicinity of the bridge wall, the top of the wall should be so shaped and of such a distance below



PLATE 18

Illustrating flush front riser casting for connecting flue uptake

Design of
Setting Walls

Bridge
Wall

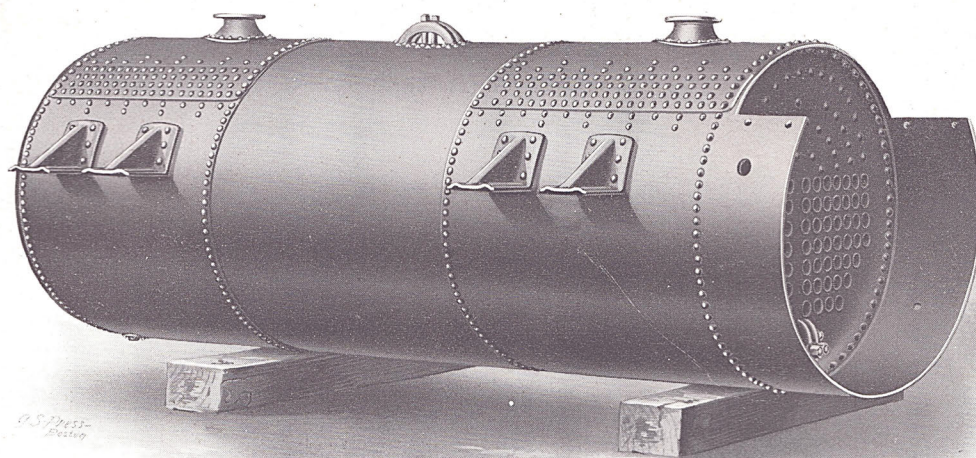


PLATE 19

Illustrating Horizontal Return Tubular Boiler made in three courses with quadruple riveted joint and four pressed steel brackets on each side

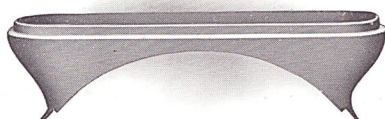


PLATE 20

Illustrating overhanging front riser casting for connecting flue uptake

the shell that the products of combustion will not strike directly against the seam. Leave at least ten or fourteen inches between the top of the bridge wall and the shell to prevent overheating of the sheets, even in the absence of seams. The top of the bridge wall should be built straight across, and not follow the contour of the shell as is sometimes done.

The combustion chamber at the rear of the bridge wall is a very important feature. It aids complete combustion; especially if bituminous coal is used. The rear edge of the bridge wall should be built vertically, and the space behind it down to about the level of the floor should be left open. The deep combustion chamber at the rear of the bridge wall causes a whirl in the air and gases coming over it and greatly aids in their proper mixture. It also increases storage capacity for the fine ash and cinder that is carried beyond the bridge wall.

The practice of filling the space behind the bridge wall cannot be too strongly condemned, for it seriously interferes with the accessibility for inspection of the most important surfaces of the boiler, and is certain to prevent complete combustion, especially if bituminous coal is used. It is easier to clean out the combustion chamber by arranging the bottom of it so that the blow-off pipe passes out below the paving. (See page 28.) The cleanout door, which is usually located in the rear wall, should be placed on a level with the paving so that no obstacle is offered to raking out the ashes. Place the blow-off pipe in a brick trough, the bricks on top being arranged so that they may be readily removed for inspection. This arrangement admits the blow-off pipe being placed above the boiler-room floor without interfering with free access to the

Combustion Chamber



PLATE 21

Illustrating our standard cleanout door and frame with cam door fastener

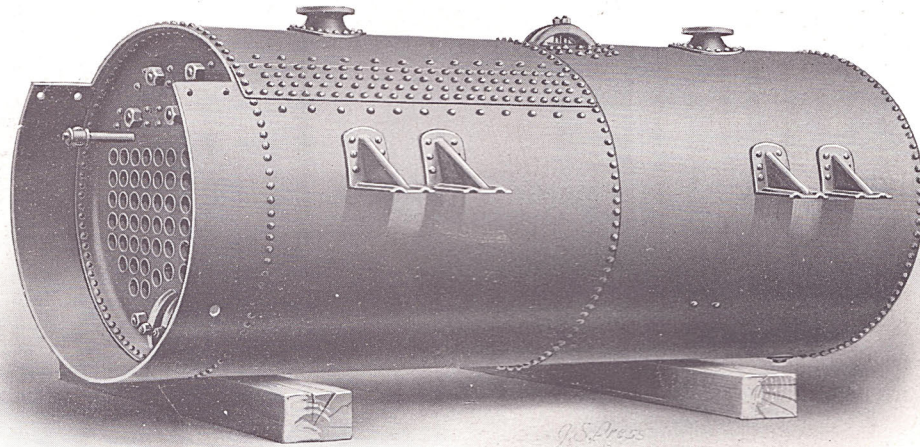


PLATE 22

Illustrating Horizontal Return Tubular Boiler made in two courses, quadruple riveted joint and four pressed steel brackets on each side

cleanout door. The vertical section of the blow-off pipe should be protected from the direct impingement of the flames by use of a pipe sleeve over it.

**Fire-brick
Lining**

Some engineers prefer to line all the inner surfaces that are swept by flame and heated gases with fire-brick, and while this makes a good and lasting setting it adds considerably to the cost. If the front wall and the side walls as far as the bridge wall are lined, together with the face of bridge wall, and the balance of the setting is laid with good, hard-burned red brick, a satisfactory and very durable job will result. Every fifth or sixth course of fire-brick should be a header course to properly bind the lining to the main wall. When laying the fire-brick care should be taken to use only the minimum amount of fire-clay for bonding.

Binder Bars

When a boiler is set with a Dutch oven, there is absolute need of binder bars or their equivalent to carry the thrust of the arch, but no such need exists with the ordinary return tubular setting where the boiler is hung, and probably not where the boiler is supported by lugs resting on the setting walls.

**Allowance for
Expansion**

Proper provision to allow freedom for expansion of the shell must be made if the cracking of the setting walls is to be prevented. The walls should be left about one inch from the shell of the boiler at all points, and this space can be closed with asbestos rope or plastic asbestos to prevent air leakage into the setting. Pockets should be left in the brickwork around the rear supporting lugs so that there will be no chance for the lugs to push against the walls. A point where clearance is of vital importance is around the pipe connection to the water column and blow-off. Unless there is proper freedom allowed at these points there is danger of the piping being broken off.

**Boilers
Supported
on Columns**

Where boilers are hung from beams and supported on columns and more than one boiler is used, a column is often placed in the dividing wall between boilers (see page 34); where this is the case too great care cannot be exercised to keep such columns from being overheated. There should be at least thirteen inches of brickwork between the column and the fire and a two-inch air space around the



PLATE 23
Illustrating cast-iron
water column

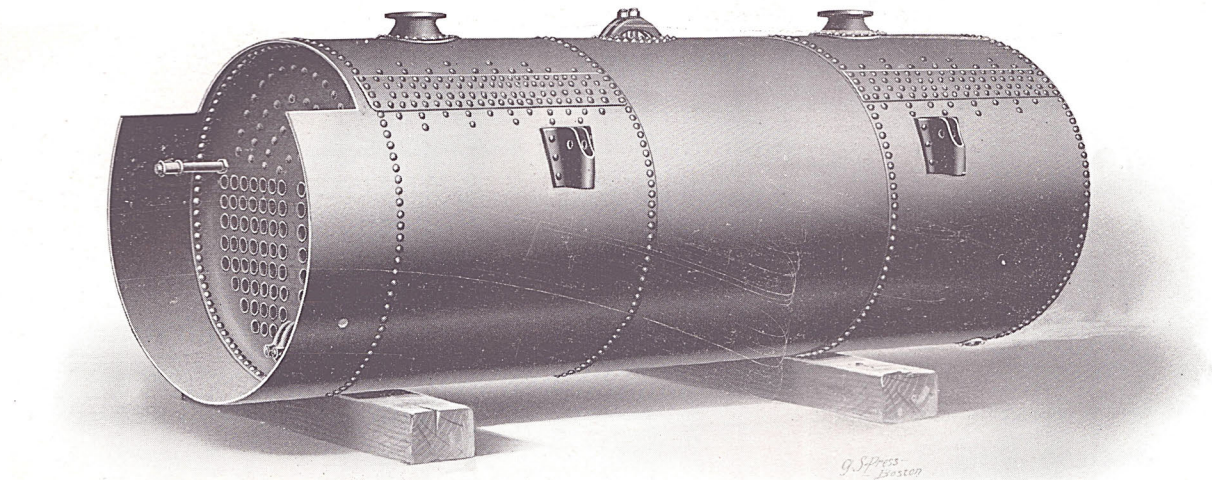


PLATE 24

Illustrating Horizontal Return Tubular Boiler made in three courses with quadruple riveted joint and pressed steel hanger pads



PLATE 25

Illustrating cast-iron rear arch tee bar

column, with free ventilation in this space. To accomplish this, air should be admitted near the bottom of the column through an open duct not less than ten inches square, and with free opening at the top. These requirements, where a column eight inches in diameter is used, mean that the minimum wall thickness between the boilers at the grate level must be thirty-eight inches.

The best covering for the exposed surface on top of a boiler, and the one that will reduce the radiation losses to a minimum, is eighty-five per cent magnesia from two to three inches thick, the outer layer being made with a hard finishing cement. A cheaper covering, but one that will resist wear better than the magnesia and still reduce the radiation losses to a low point, is made of asbestos, but it should be of good grade.

In setting a boiler give particular attention to the proper location of the water column; place it so that the lowest gauge cock is at least three inches above the tops of the tubes and the lowest point of vision in the gauge glass at least one inch above the tops of the tubes. The latter point is of great importance, for it is often a temptation for an engineer to take chances as long as he can see water in the glass, although he may realize that it is lower than safety demands, and it is therefore best to prevent the water level from being seen after the lowest point for safety has been reached.

No matter how carefully a boiler setting has been built, it can be badly damaged and cracked by carelessness in starting up. No setting which has just been completed should be operated in regular service without a thorough drying out; this drying is accomplished by keeping a slow fire under the boiler for at least a week, and longer if circumstances will permit. The interior of a new boiler should be thoroughly cleaned of oil, dirt, etc., and the best way to accomplish this is to boil slowly with a strong solution of soda ash (fifty to sixty pounds for each hundred boiler horse-power), and in this way the drying of the setting walls and the cleaning of the boiler can be accomplished simultaneously.

**Covering the Top
of the Boiler**

**Setting
Water Columns**

Starting Boilers

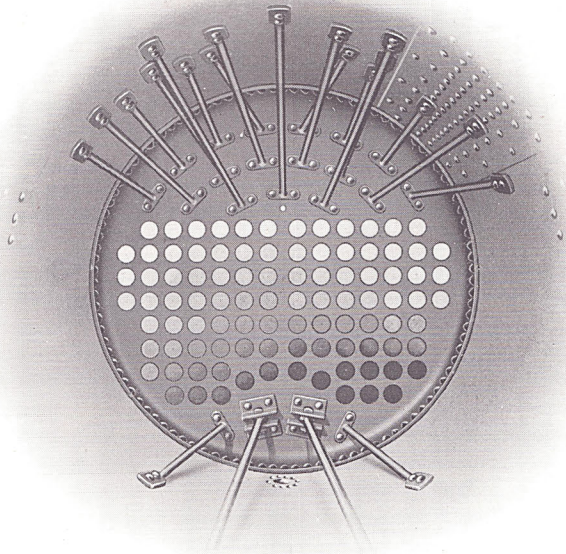


PLATE 26

Illustrating rear head construction and arrangement of bracing of a Horizontal Return Tubular Boiler seen from the inside of the boiler

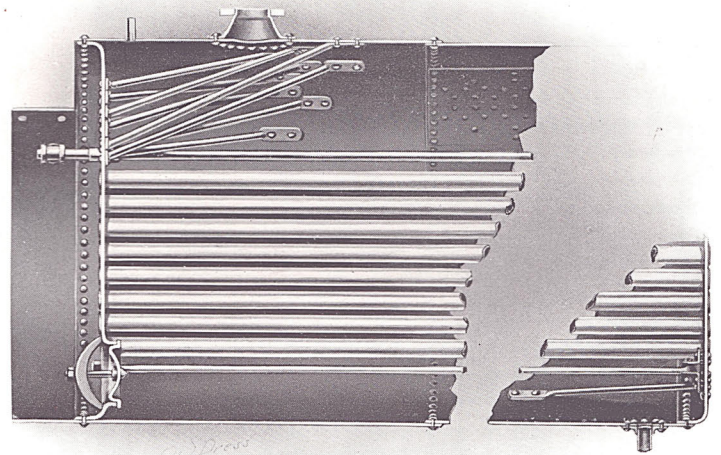


PLATE 27

Illustrating longitudinal section of Horizontal Return Tubular Boiler and arrangement of bracing

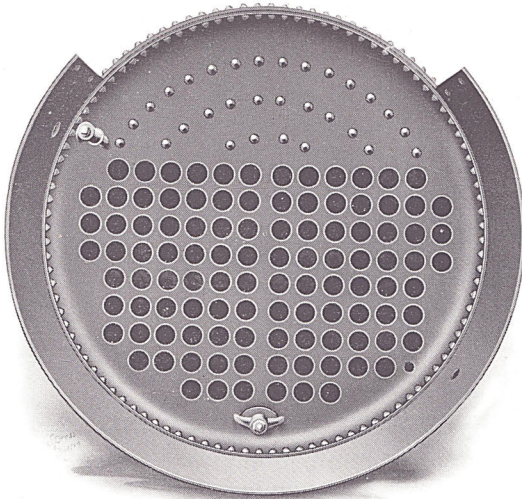


PLATE 28

Illustrating front view of Horizontal Return Tubular Boiler with handhole below the tubes

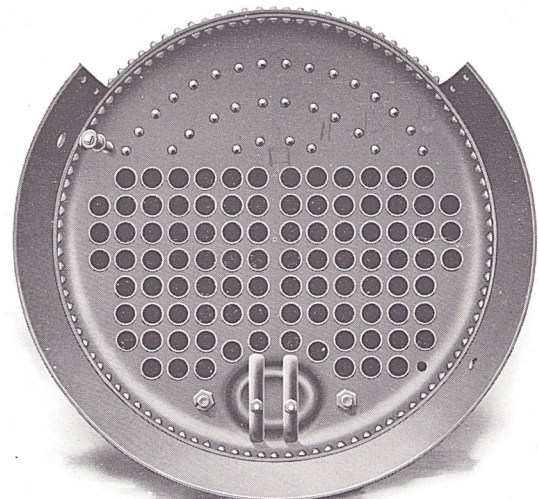


PLATE 29

Illustrating front view of Horizontal Return Tubular Boiler with manhole below the tubes

Laying up a Boiler

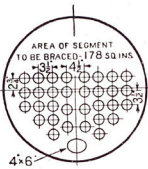
Unless care is used in laying up a boiler when idle it will deteriorate more rapidly than when in use. To properly prepare a boiler for long idleness it should be thoroughly cleaned, both externally and internally, sweeping off all soot and ashes from the tubes and plates. All openings such as handholes, manholes, etc., should be left open to allow as free circulation of air as possible. Under no circumstances should a boiler be laid up with water in it, as this causes very rapid external corrosion, due to sweating.

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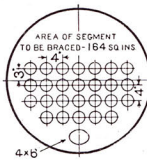
TABLE GIVING HORSE-POWER RATING OF HORIZONTAL RETURN TUBULAR BOILERS

Number	Horse-power	Square Feet of Water Heating Surface	Diameter of Boiler		Tubes			Manhole or Handhole in Front Head Below the Tubes	Horse-power for Each Additional Foot in Length of Tubes	‡Thickness of Shell and Heads for Various Working Pressures								Style of Riveted Joint on Horizontal Seams All Joints are of the Butt Strap Type	Size of Nozzles for Steam and Safety Valve	Size of Feed Pipe	Size of Blow-off Pipe	Length of Grate	Width of Grate	Ratio of Grate Surface to Heating Surface																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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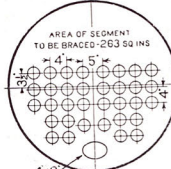
THE BIGELOW COMPANY, NEW HAVEN, CONNECTICUT



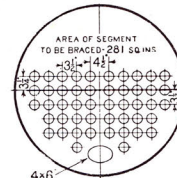
36" DIAM.
32 2½" TUBES



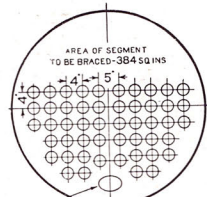
36" DIAM.
26 3" TUBES



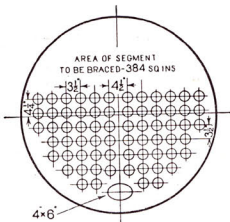
42" DIAM.
34 3" TUBES



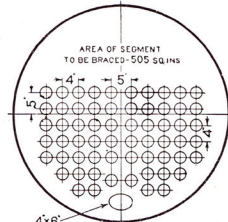
42" DIAM.
48 2½" TUBES



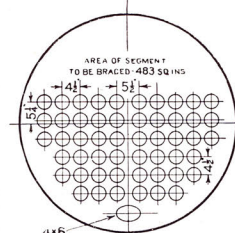
48" DIAM.
50 3" TUBES



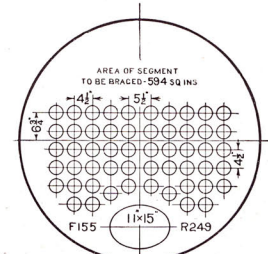
48" DIAM.
68 2½" TUBES



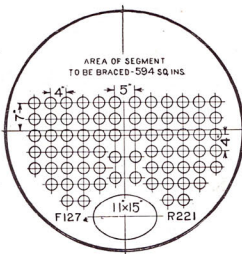
54" DIAM.
62 3" TUBES



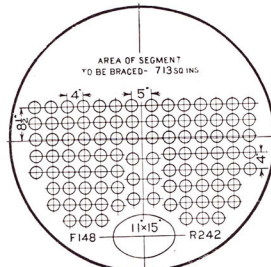
54" DIAM.
52 3½" TUBES



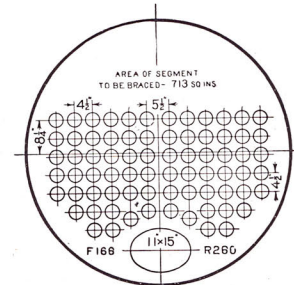
60" DIAM.
54 3½" TUBES



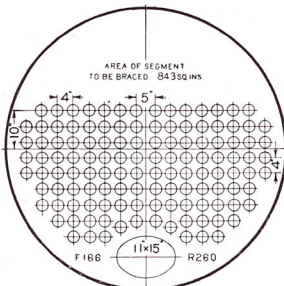
60" DIAM.
72 3" TUBES



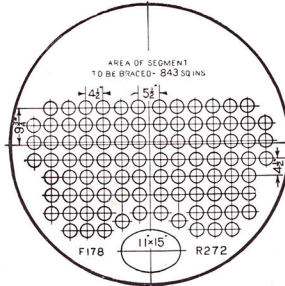
66" DIAM.
98 3" TUBES



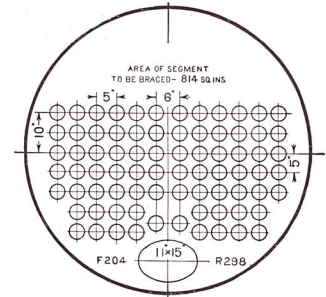
66" DIAM.
74 3½" TUBES



72" DIAM.
124 3" TUBES

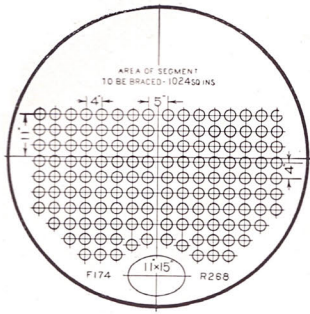


72" DIAM.
96 3½" TUBES

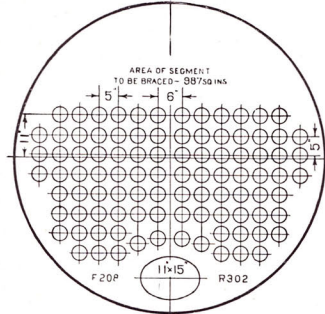


72" DIAM.
78 4" TUBES

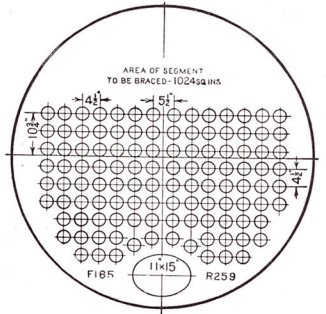
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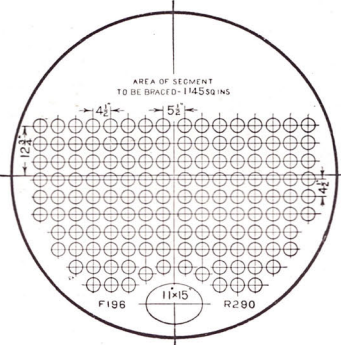
78" DIAM.
144 3" TUBES



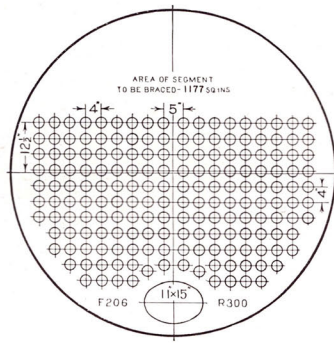
78" DIAM.
96 4" TUBES



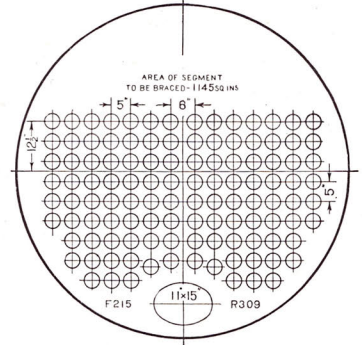
78" DIAM.
114 3 1/2" TUBES



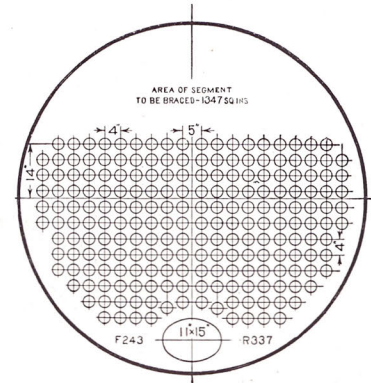
84" DIAM.
142 3 1/2" TUBES



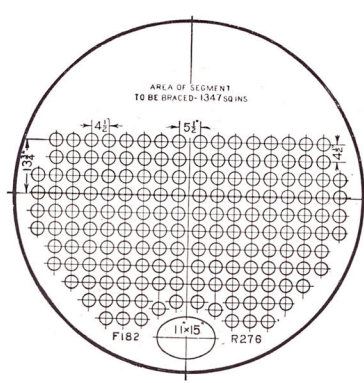
84" DIAM.
180 3" TUBES



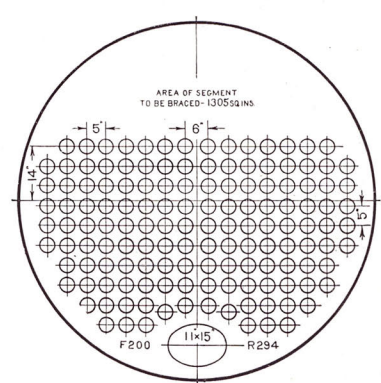
84" DIAM.
114 4" TUBES



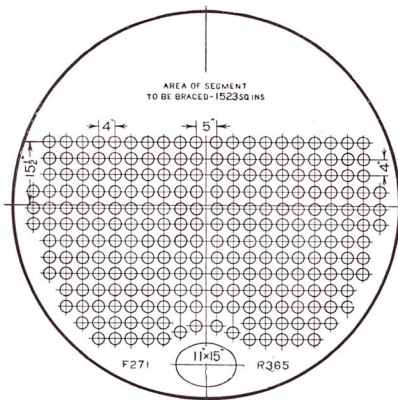
90" DIAM.
210 3" TUBES



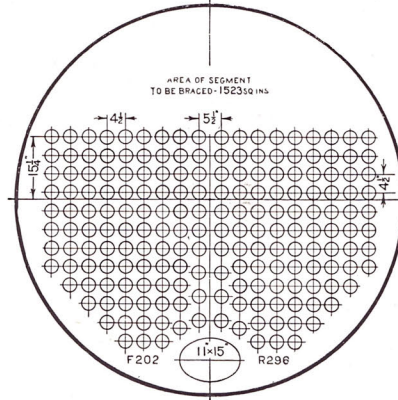
90" DIAM.
168 3 1/2" TUBES



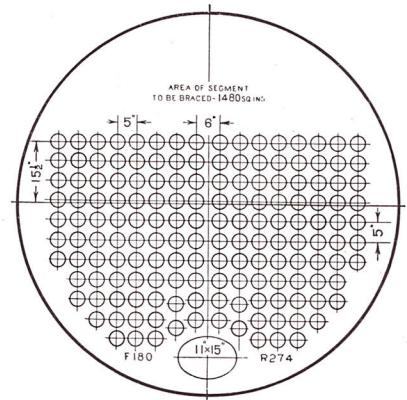
90" DIAM.
140 4" TUBES



96" DIAM.
248 3" TUBES



96" DIAM.
190 3 1/2" TUBES



96" DIAM.
158 4" TUBES

Data on Bracing Horizontal Return Tubular Boilers for 100, 125 and 150 lbs. Pressure

BOILERS WITH HANDHOLE IN FRONT HEAD

[illegible]

BOILERS WITH MANHOLE IN FRONT HEAD

[illegible]

* Working load on braces figured not to exceed 7500 lbs. per sq. in. of cross section.

There are two 1 1/4" diameter Weldless Crowfoot Braces below the tubes on the rear head in addition to the through braces.

THE BIGELOW COMPANY, NEW HAVEN, CONNECTICUT

Test made under supervision of Mr. E. L. Fletcher of the Fletcher Engineering Co., Bridgeport, Conn., at
the main plant of the Bridgeport Brass Co., March 21 and 22, 1911

Apparatus inspected consisted of five (5) boilers, known as Nos. 1, 2, 3, 5 and 6 of 150 H.P. each.

No special arrangements were made for this test, the firing of the boilers, filling with water, supplying of steam all being carried on in the every-day manner.

Being carried off in the every-day manner.		36 sq. ft.
Grate surface of each boiler is		1,614 sq. ft.
Water heating surface of each boiler is		
Duration of trial 24 hours, Operation of shop, 10 hours.		
1. Weight of coal as fired, 7 A.M. to 7 P.M., bituminous		30,694 lbs.
2. Weight of coal as fired, 7 P.M. to 7 A.M.		14,612 lbs.
3. Weight of coal as fired, 1 day (24 hours)		45,306 lbs.
4. Percentage of moisture in coal		2.1%
5. Total weight of dry coal consumed		44,355 lbs.
6. Total ash and refuse		3,517 lbs.
7. (a) Percentage of ash and refuse in coal by weight		7.9%
(b) Percentage of ash and refuse in coal by chemical analysis		6.25%
9. Total weight of water fed to boiler 7 A.M. to 7 P.M.		343,542 lbs.
10. Total weight of water fed to boiler 7 P.M. to 7 A.M.		100,231 lbs.
11. Total weight of water fed to boiler 1 day (24 hours)		443,771 lbs.
12. Water actually evaporated corrected for moisture		439,379 lbs.
13. Factor of evaporation		{ 1.0605 day 1.0621 night
14. Equivalent water evaporated into dry steam from and at 212° (Item (9 and 10) x Item 13)	364,325 day 106,455 night	470,780 lbs.
15. Dry coal consumed per hour 7 A.M. to 7 P.M. (Item 1 corrected for moisture)		2,504 lbs.
16. Dry coal consumed per hour 7 P.M. to 7 A.M. (Item 2 corrected for moisture)		1,192 lbs.
17. Dry coal consumed per hour 1 day (24 hours)		1,848 lbs.
18. Dry coal consumed per square foot of grate surface per hour 7 A.M. to 7 P.M.		13.9 lbs.
19. Dry coal consumed per square foot of grate surface, average for 24 hours		10.3 lbs.
20. Water evaporated per hour corrected for quality of steam 7 A.M. to 7 P.M.		28,483 lbs.
21. Water evaporated per hour corrected for quality of steam 7 P.M. to 7 A.M.		8,132 lbs.
22. Water evaporated per hour corrected for quality of steam for 24-hour day		18,307 lbs.
23. Equivalent evaporation per hour from and at 212° 7 A.M. to 7 P.M.		30,360 lbs.
24. Equivalent evaporation per hour from and at 212° for night		8,844 lbs.
25. Equivalent evaporation per hour from and at 212° per sq. ft. of water heating surface (5 boilers)		
	days	3.76 lbs.
	nights	1.01 lbs.
26. Average steam pressure by gauge (corrected), lbs. per sq. in.,	days	106.5 lbs.
	nights	188.5 lbs.
27. Average temperature of feed water entering boiler (deg. Fahr.)	days	193.4
	nights	188.3
28. Average temperature of gases from boilers 7 A.M. to 7 P.M. (deg. Fahr.)		{ 420 east 345 west
29. Average temperature of gases from boilers 7 P.M. to 7 A.M. (deg. Fahr.)		{ 256 east 324 west
30. Force of draft between dampers and boilers (east battery), day		.42 in.
31. Force of draft between dampers and boilers (west battery), day		.50 in.
32. Force of draft between dampers and boilers (east battery), night		.25 in.
33. Force of draft between dampers and boilers (west battery), night		.27 in.
34. Temperature of external air (day) (deg. Fahr.)		52
35. Percentage of moisture in steam (Averages — see table) (day)		.9%
	(night)	1.8%
36. Horse-power developed — Item 23 and 24 (day)	34.5 34.5 (night)	880 H.P.
37. Builder's rated horse-power 150 H.P. each		257 H.P.
38. Percentage of builder's rated H.P. developed		750 H.P.
39. Water apparently evaporated under actual conditions per pound of coal as fired — Item $\frac{9}{1}$ day		11.2 lbs.
	$\frac{10}{2}$ night	6.8 lbs.
40. Equivalent evaporation from and at 212° per pound of coal as fired — Item $\frac{14}{1}$ day		11.8 lbs.
	$\frac{14}{2}$ night	7.3 lbs.
41. Equivalent evaporation from and at 212° per pound of dry coal — $\frac{14}{5}$ day		12.1 lbs.
	$\frac{14}{5}$ night	7.4 lbs.
42. Equivalent evaporation from and at 212° per pound of combustible coal for 24 hours run. Item $\frac{14}{5-6}$		11.5 lbs.
43. Calorific value of dry coal per pound (as figured)		14,157 Heat Units
44. Calorific value of dry coal per pound (Bomb Calorimeter)		14,890 B.T.U.
45. Calorific value of the combustible per pound		15,820 B.T.U.
46. Cost to evaporate 1,000 pounds of water from and at 212° with coal at \$1.00 per long ton, water at 37c. per 1,000 cu. ft. (labor not included) 7 A.M. to 7 P.M.		.0439 cent
	7 P.M. to 7 A.M.	.0672 cent
	24 hours	.0447 cent

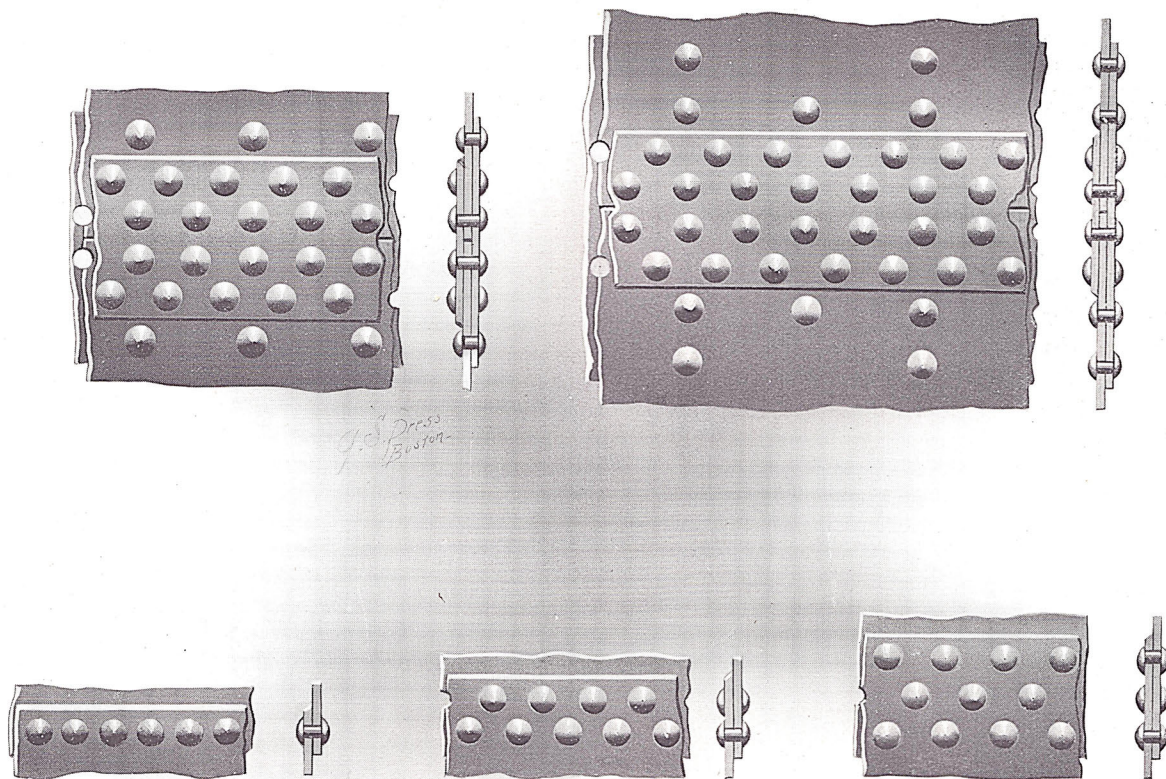
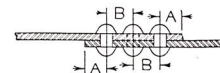
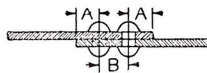
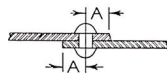
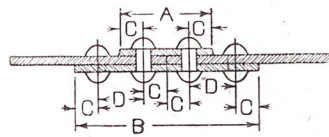


PLATE 30
Illustrating various lap and butt type joints



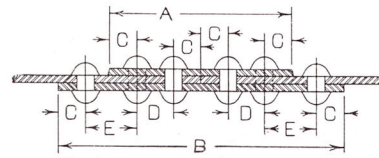
SINGLE RIVETED LAP JOINTS					DOUBLE RIVETED LAP JOINTS						TRIPLE RIVETED LAP JOINTS					
Thickness of Plate Inches	Diameter of Rivet Hole Inches	Efficiency of Joint Per Cent	Pitch of Rivets Inches	Dimension A Inches	Thickness of Plate Inches	Diameter of Rivet Hole Inches	Efficiency of Joint Per Cent	Pitch of Rivets Inches	Dimension A Inches	Dimension B Inches	Thickness of Plate Inches	Diameter of Rivet Hole Inches	Efficiency of Joint Per Cent	Pitch of Rivets Inches	Dimension A Inches	Dimension B Inches
$\frac{1}{4}$	$\frac{11}{16}$	60.7	$1\frac{3}{4}$	$1\frac{1}{16}$	$\frac{1}{4}$	$\frac{11}{16}$	72.5	$2\frac{1}{2}$	$1\frac{1}{16}$	$1\frac{3}{4}$	$\frac{1}{4}$	$\frac{11}{16}$	77.0	3	$1\frac{1}{16}$	$1\frac{7}{8}$
$\frac{9}{32}$	$\frac{11}{16}$	55.5	$1\frac{3}{4}$	$1\frac{1}{16}$	$\frac{9}{32}$	$\frac{11}{16}$	72.5	$2\frac{1}{2}$	$1\frac{1}{16}$	$1\frac{3}{4}$	$\frac{9}{32}$	$\frac{11}{16}$	77.0	3	$1\frac{1}{16}$	$1\frac{7}{8}$
$\frac{5}{16}$	$\frac{13}{16}$	57.5	$2\frac{1}{8}$	$1\frac{1}{4}$	$\frac{5}{16}$	$\frac{13}{16}$	71.7	$2\frac{7}{8}$	$1\frac{1}{4}$	$1\frac{7}{8}$	$\frac{5}{16}$	$\frac{11}{16}$	78.8	$3\frac{1}{4}$	$1\frac{1}{16}$	$1\frac{7}{8}$
$\frac{11}{32}$	$\frac{13}{16}$	52.3	$2\frac{1}{8}$	$1\frac{1}{4}$	$\frac{11}{32}$	$\frac{13}{16}$	71.7	$2\frac{7}{8}$	$1\frac{1}{4}$	$1\frac{7}{8}$	$\frac{11}{32}$	$\frac{13}{16}$	75.0	$3\frac{1}{4}$	$1\frac{1}{4}$	$2\frac{1}{8}$
$\frac{3}{8}$	$\frac{15}{16}$	58.3	$2\frac{1}{4}$	$1\frac{7}{16}$	$\frac{3}{8}$	$\frac{15}{16}$	70.0	$3\frac{1}{8}$	$1\frac{7}{16}$	2	$\frac{3}{8}$	$\frac{13}{16}$	75.0	$3\frac{1}{4}$	$1\frac{1}{4}$	$2\frac{1}{8}$
$\frac{13}{32}$	$\frac{15}{16}$	55.6	$2\frac{1}{4}$	$1\frac{7}{16}$	$\frac{13}{32}$	$\frac{15}{16}$	70.0	$3\frac{1}{8}$	$1\frac{7}{16}$	2	$\frac{13}{32}$	$\frac{13}{16}$	75.0	$3\frac{1}{4}$	$1\frac{1}{4}$	$2\frac{1}{8}$
$\frac{7}{16}$	$1\frac{1}{16}$	57.5	$2\frac{1}{2}$	$1\frac{5}{8}$	$\frac{7}{16}$	$1\frac{1}{16}$	68.5	$3\frac{3}{8}$	$1\frac{5}{8}$	$2\frac{1}{8}$	$\frac{7}{16}$	$\frac{15}{16}$	75.0	$3\frac{3}{4}$	$1\frac{7}{16}$	$2\frac{3}{8}$
$\frac{15}{32}$	$1\frac{1}{16}$	55.7	$2\frac{1}{2}$	$1\frac{5}{8}$	$\frac{15}{32}$	$1\frac{1}{16}$	69.6	$3\frac{1}{2}$	$1\frac{5}{8}$	$2\frac{1}{8}$	$\frac{15}{32}$	$\frac{15}{16}$	75.0	$3\frac{3}{4}$	$1\frac{7}{16}$	$2\frac{3}{8}$
$\frac{1}{2}$	$1\frac{1}{16}$	52.2	$2\frac{1}{2}$	$1\frac{5}{8}$	$\frac{1}{2}$	$1\frac{1}{16}$	69.6	$3\frac{1}{2}$	$1\frac{5}{8}$	$2\frac{1}{8}$	$\frac{1}{2}$	$\frac{15}{16}$	75.0	$3\frac{3}{4}$	$1\frac{7}{16}$	$2\frac{3}{8}$

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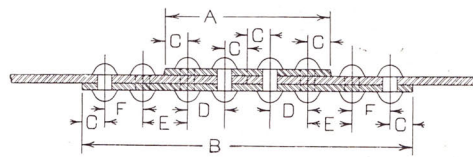
DOUBLE RIVETED BUTT STRAP JOINTS

Thickness of Plate Inches	Diameter of Rivet Hole Inches	Efficiency of Joint Per Cent	Long Pitch Inches	Short Pitch Inches	Thickness of Strap Inches	Width of Out-side Strap A Inches	Width of In-side Strap B Inches	Dimension C Inches	Dimension D Inches
1/4	11/16	82.8	4	2	1/4	4 1/4	8 3/8	1 1/16	2 1/16
5/16	1 1/8	81.5	4	2	5/16	4 1/4	8 3/8	1 1/16	2 1/16
3/8	1 1/8	81.9	4 1/2	2 1/4	3/8	5	9 7/8	1 1/4	2 1/16
7/16	1 3/8	81.9	4 1/2	2 1/4	7/16	5	9 7/8	1 1/4	2 1/16
1/2	1 3/8	81.9	4 1/2	2 1/4	1/2	5	9 7/8	1 1/4	2 1/16
5/8	1 3/8	81.0	4 1/2	2 1/4	5/8	5 3/4	11 3/8	1 7/16	2 1/16
3/4	1 3/8	81.2	5	2 1/2	3/4	5 3/4	11 3/8	1 7/16	2 1/16
7/8	1 3/8	81.2	5	2 1/2	7/8	5 3/4	11 3/8	1 7/16	2 1/16
1	1 3/8	80.6	5 1/2	2 3/4	1	6 1/2	12 7/8	1 5/8	3 1/16
1 1/16	1 3/8	80.6	5 1/2	2 3/4	1 1/16	6 1/2	12 7/8	1 5/8	3 1/16



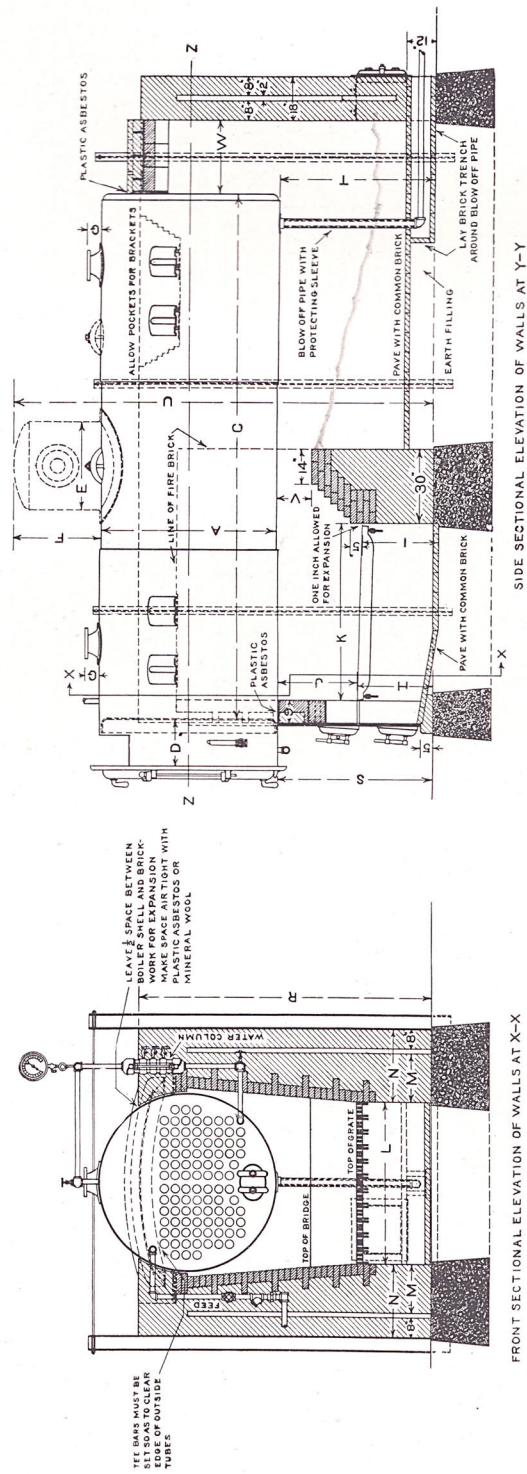
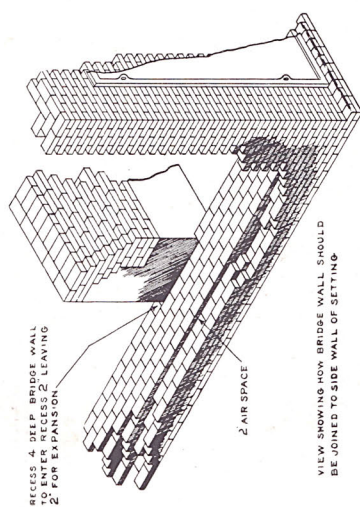
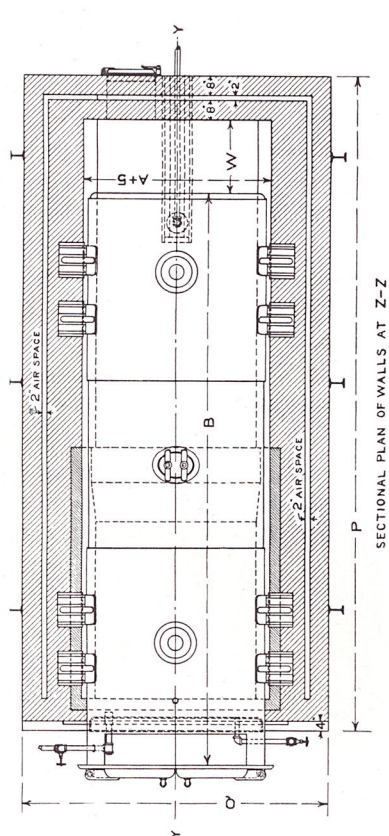
TRIPLE RIVETED BUTT STRAP JOINTS

Thickness of Plate Inches	Diameter of Rivet Hole Inches	Efficiency of Joint Per Cent	Long Pitch Inches	Short Pitch Inches	Thickness of Strap Inches	Width of Out-side Strap A Inches	Width of In-side Strap B Inches	Dimension C Inches	Dimension D Inches	Dimension E Inches
1/4	11/16	86.2	5	2 1/2	1/4	8	12 1/8	1 1/16	1 7/8	2 1/16
5/16	1 1/8	86.2	5	2 1/2	5/16	8	12 1/8	1 1/16	1 7/8	2 1/16
3/8	1 1/8	87.0	6 1/4	3 1/8	3/8	9	13 7/8	1 1/4	2	2 1/16
7/16	1 3/8	87.0	6 1/4	3 1/8	7/16	9	13 7/8	1 1/4	2	2 1/16
1/2	1 3/8	87.5	6 1/2	3 1/4	1/2	9	13 7/8	1 1/4	2	2 1/16
5/8	1 3/8	87.5	6 1/2	3 1/4	5/8	9	13 7/8	1 1/4	2	2 1/16
3/4	1 3/8	86.1	6 3/4	3 3/8	3/4	10	15 5/8	1 1/2	2 1/8	2 1/16
7/8	1 3/8	86.6	7	3 3/4	7/8	10	15 5/8	1 1/2	2 1/8	2 1/16
1	1 3/8	87.5	7 1/2	3 3/4	1	10	15 5/8	1 1/2	2 1/8	2 1/16
1 1/16	1 3/8	87.5	7 1/2	3 3/4	1 1/16	10	15 5/8	1 1/2	2 1/8	2 1/16
1 1/8	1 3/8	86.2	7 3/4	3 7/8	1 1/8	11 1/8	17 1/2	1 5/8	2 3/8	3 1/16
1 1/4	1 3/8	86.2	7 3/4	3 7/8	1 1/4	11 1/8	17 1/2	1 5/8	2 3/8	3 1/16
1 1/2	1 3/8	86.0	7 3/4	3 7/8	1 1/2	11 1/8	17 1/2	1 5/8	2 3/8	3 1/16
1 3/4	1 3/8	85.4	7 3/4	3 7/8	1 3/4	11 1/8	17 1/2	1 5/8	2 3/8	3 1/16
1 7/8	1 3/8	84.6	7 3/4	3 7/8	1 7/8	12	19 1/8	1 11/16	2 3/8	3 1/16
2	1 3/8	84.0	7 3/4	3 7/8	2	12	19 1/8	1 11/16	2 3/8	3 1/16
2 1/16	1 3/8	83.9	8	4	2 1/16	12	19 1/8	1 11/16	2 3/8	3 1/16



QUADRUPLE RIVETED BUTT STRAP JOINTS

Thickness of Plate Inches	Thickness of Straps Inches	Efficiency of Joint Per Cent	Diameter of Rivet Hole Inches	Long Pitch Inches	Middle Pitch Inches	Short Pitch Inches	Dimension A Inches	Dimension B Inches	Dimension C Inches	Dimension D Inches	Dimension E Inches	Dimension F Inches
1/4	1/4	93.7	11/16	11	5 1/2	2 3/4	8	16 1/8	1 1/16	1 7/8	2 1/16	2
5/16	5/16	94.2	1 1/8	12	6	3	8	16 1/8	1 1/16	1 7/8	2 1/16	2
3/8	3/8	94.2	1 1/8	14	7	3 1/2	9 1/4	18 5/8	1 1/4	2 1/8	2 1/16	2 1/4
7/16	7/16	94.2	1 1/8	14	7	3 1/2	9 1/4	18 5/8	1 1/4	2 1/8	2 1/16	2 1/4
1/2	1/2	94.2	1 1/8	14	7	3 1/2	9 1/4	18 5/8	1 1/4	2 1/8	2 1/16	2 1/4
5/8	5/8	94.3	1 1/8	14 1/4	7 1/8	3 1/2	9 1/4	18 5/8	1 1/4	2 1/8	2 1/16	2 1/4
3/4	3/4	93.7	1 1/8	15	7 1/2	3 3/4	10 1/4	20 5/8	1 1/2	2 1/4	2 3/8	2 3/4
7/8	7/8	94.0	1 1/8	15 3/4	7 7/8	3 1/2	10 1/4	20 5/8	1 1/2	2 1/4	2 3/8	2 3/4
1	1	94.0	1 1/8	15 3/4	7 7/8	3 1/2	10 1/4	20 5/8	1 1/2	2 1/4	2 3/8	2 3/4
1 1/16	1 1/16	93.4	1 1/8	15 3/4	7 7/8	3 1/2	10 1/4	20 5/8	1 1/2	2 1/4	2 3/8	2 3/4
1 1/8	1 1/8	93.3	1 1/8	16	8	4	11 1/8	22 3/4	1 5/8	2 5/8	3 1/16	2 5/8
1 1/4	1 1/4	93.0	1 1/8	16	8	4	11 1/8	22 3/4	1 5/8	2 5/8	3 1/16	2 5/8
1 1/2	1 1/2	92.1	1 1/8	16	8	4	11 1/8	22 3/4	1 5/8	2 5/8	3 1/16	2 5/8
1 3/4	1 3/4	92.5	1 1/8	16	8	4	12	24 7/8	1 11/16	2 3/8	3 1/16	2 7/8
1 7/8	1 7/8	91.6	1 1/8	16	8	4	12	24 7/8	1 11/16	2 3/8	3 1/16	2 7/8
2	2	90.7	1 1/8	16	8	4	12	24 7/8	1 11/16	2 3/8	3 1/16	2 7/8
2 1/16	2 1/16	89.9	1 1/8	16	8	4	12	24 7/8	1 11/16	2 3/8	3 1/16	2 7/8
2 1/8	2 1/8	90.1	1 1/8	16	8	4	12 7/8	27	2	2 7/16	3 1/16	3 1/8
2 1/4	2 1/4	89.3	1 1/8	16	8	4	12 7/8	27	2	2 7/16	3 1/16	3 1/8
2 3/8	2 3/8	88.5	1 1/8	16	8	4	12 7/8	27	2	2 7/16	3 1/16	3 1/8
2 1/2	2 1/2	87.8	1 1/8	16	8	4	12 7/8	27	2	2 7/16	3 1/16	3 1/8
2 5/8	2 5/8	87.3	1 1/8	16 1/4	8 1/8	4 1/16	12 7/8	27	2	2 7/16	3 1/16	3 1/8
2 3/4	2 3/4	86.6	1 1/8	16 1/4	8 1/8	4 1/16	12 7/8	27	2	2 7/16	3 1/16	3 1/8
2 7/8	2 7/8	86.6	1 1/8	16 1/4	8 1/8	4 1/16	12 7/8	27	2	2 7/16	3 1/16	3 1/8
3	3	86.2	1 1/8	16 1/2	8 1/4	4 1/8	13 3/4	29 1/8	2 3/16	2 1/2	4 1/16	3 3/8
3 1/16	3 1/16	85.6	1 1/8	16 1/2	8 1/4	4 1/8	13 3/4	29 1/8	2 3/16	2 1/2	4 1/16	3 3/8
3 1/8	3 1/8	85.2	1 1/8	16 3/4	8 3/8	4 3/16	13 3/4	29 1/8	2 3/16	2 1/2	4 1/16	3 3/8
3 1/4	3 1/4	84.7	1 1/8	16 3/4	8 3/8	4 3/16	13 3/4	29 1/8	2 3/16	2 1/2	4 1/16	3 3/8
3 1/2	3 1/2	84.4	1 1/8	17	8 1/2	4 1/4	13 3/4	29 1/4	2 3/16	2 1/2	4 1/16	3 3/8
3 3/4	3 3/4	83.9	1 1/8	17	8 1/2	4 1/4	13 3/4	29 1/4	2 3/16	2 1/2	4 1/16	3 3/8
3 5/8	3 5/8	83.4	1 1/8	17	8 1/2	4 1/4	13 3/4	29 1/4	2 3/16	2 1/2	4 1/16	3 3/8
4	4	83.5	1 1/8	17 1/2	8 3/4	4 1/2	13 7/8	29 1/4	2 3/16	2 1/2	4 1/16	3 3/8

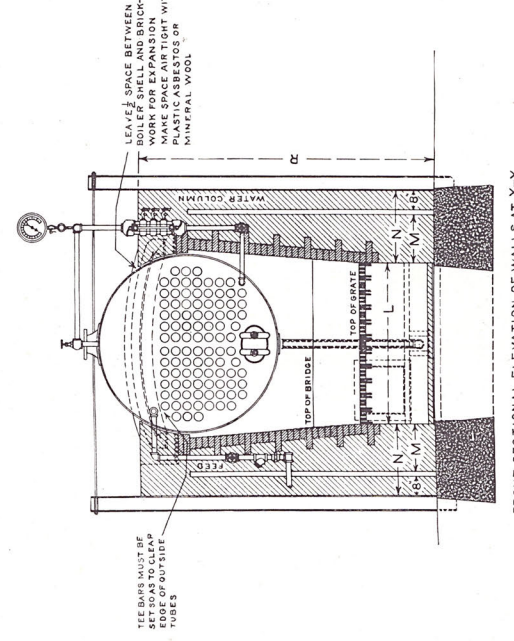
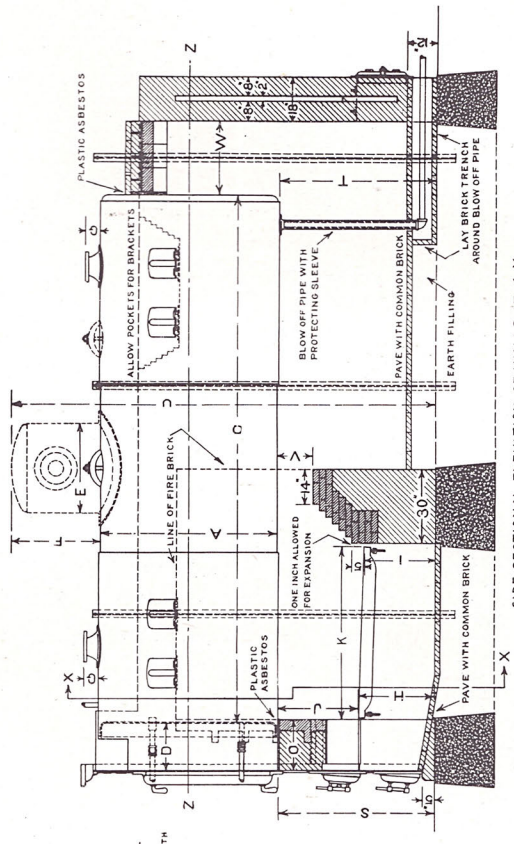
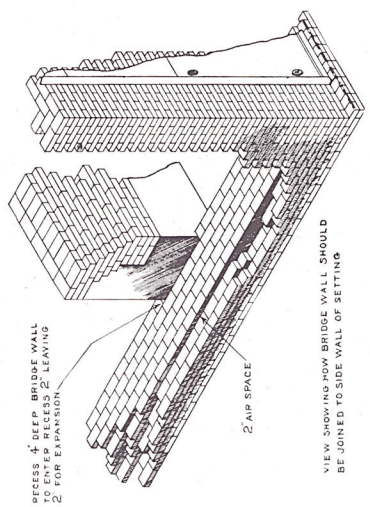
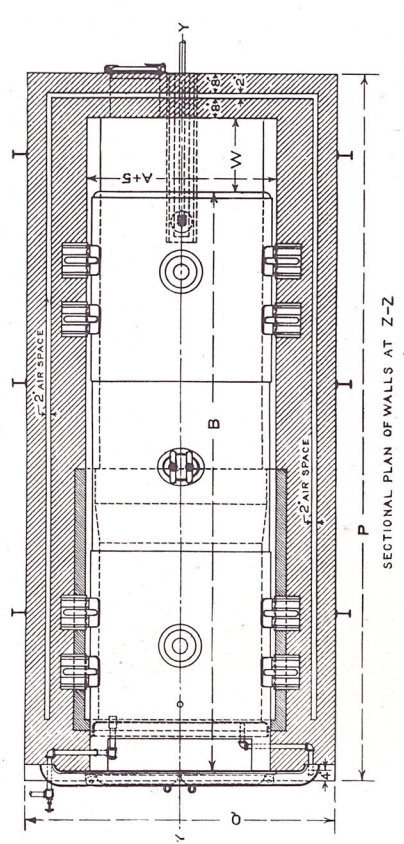


Setting plan of Horizontal Return Tubular Boiler set with overhanging front and boiler set on brackets
See table, page 29

MEASUREMENTS FOR SETTING HORIZONTAL RETURN TUBULAR BOILERS WITH OVERHANGING FRONTS

SEE DIAGRAM FOR THIS TABLE ON OPPOSITE PAGE

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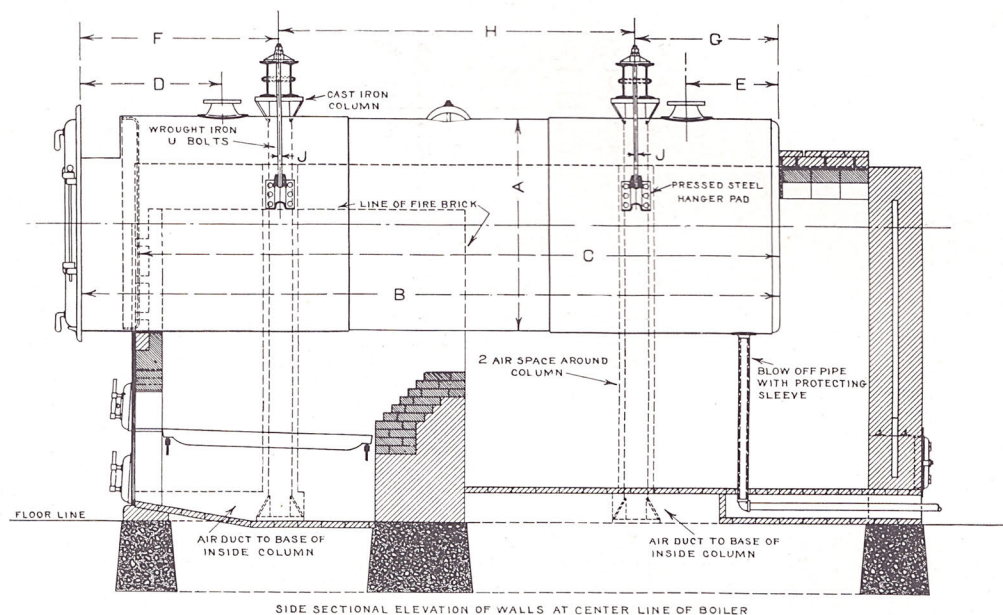


Setting plan of Horizontal Return Tubular Boiler set with flush front and boiler set on brackets.
See table, page 31

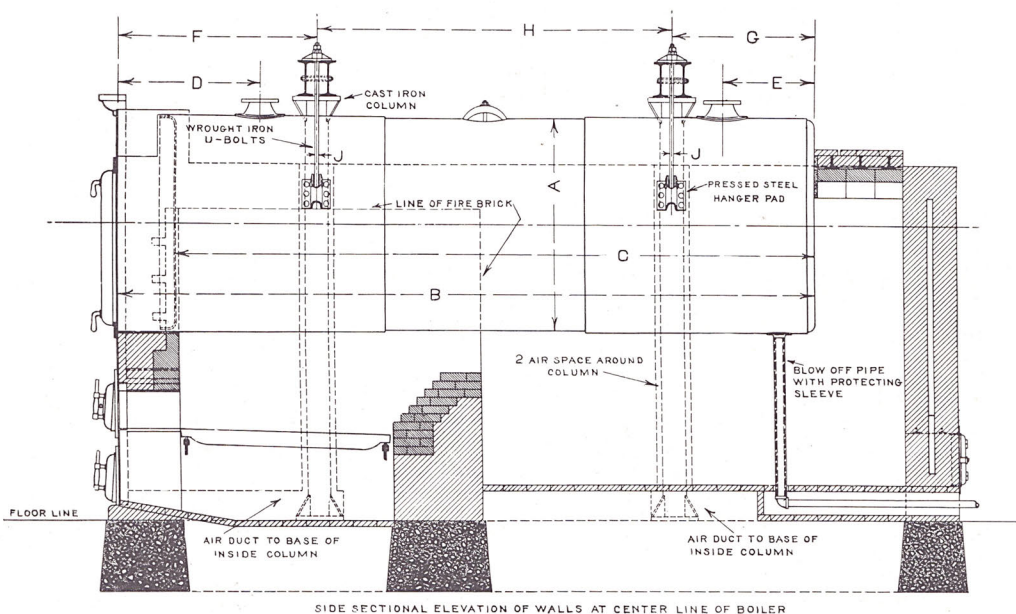
MEASUREMENTS FOR SETTING HORIZONTAL RETURN TUBULAR BOILERS WITH FULL FLUSH FRONTS

SEE DIAGRAM FOR THIS TABLE ON OPPOSITE PAGE

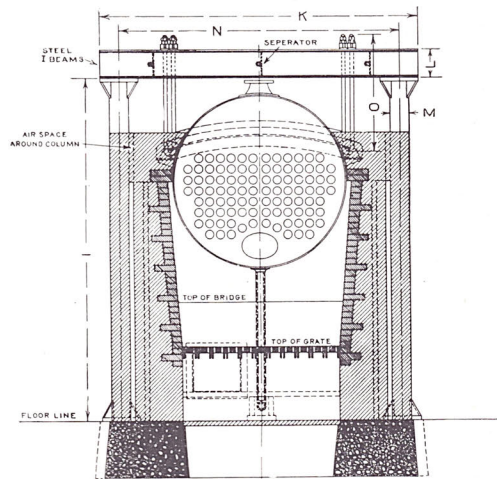
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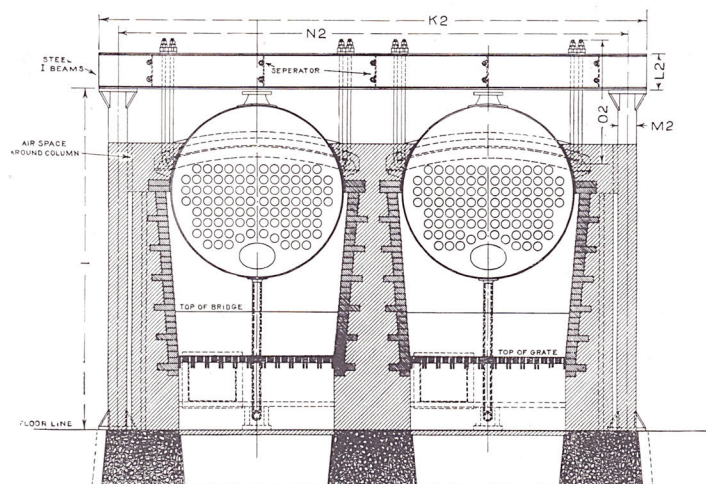
Setting plan of Horizontal Return Tubular Boiler with overhanging front and boiler suspended from I beams resting on columns. See table, page 35



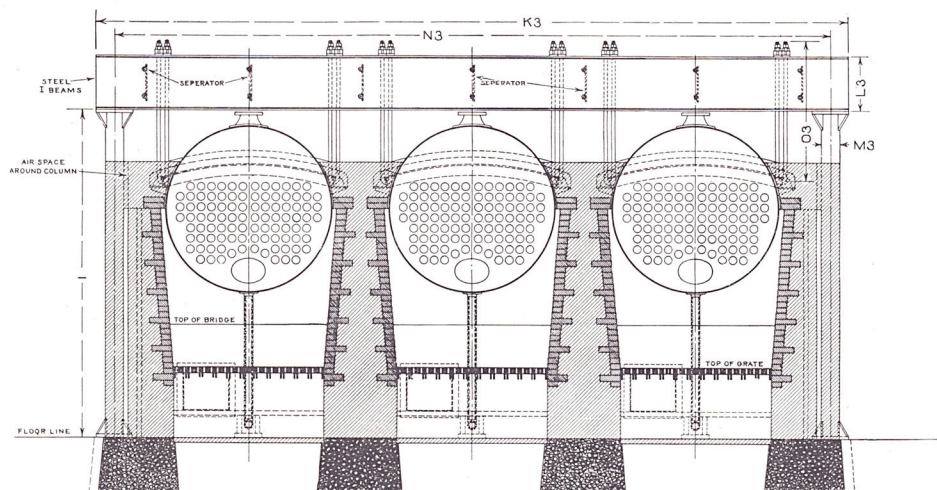
Setting plan of Horizontal Return Tubular Boiler with flush front and boiler suspended from I beams and resting on columns. See table, page 35



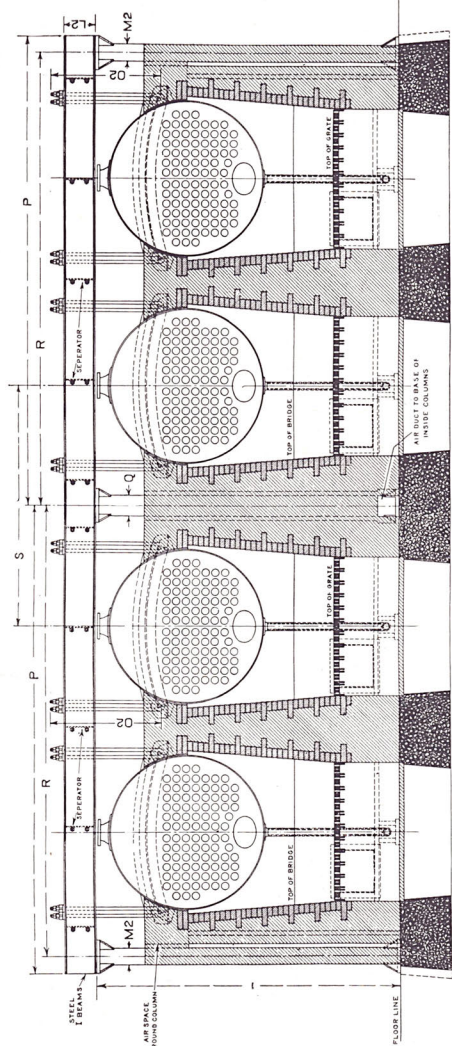
Section of one Horizontal Return Tubular Boiler suspended from I beams resting on columns.
See table, page 35



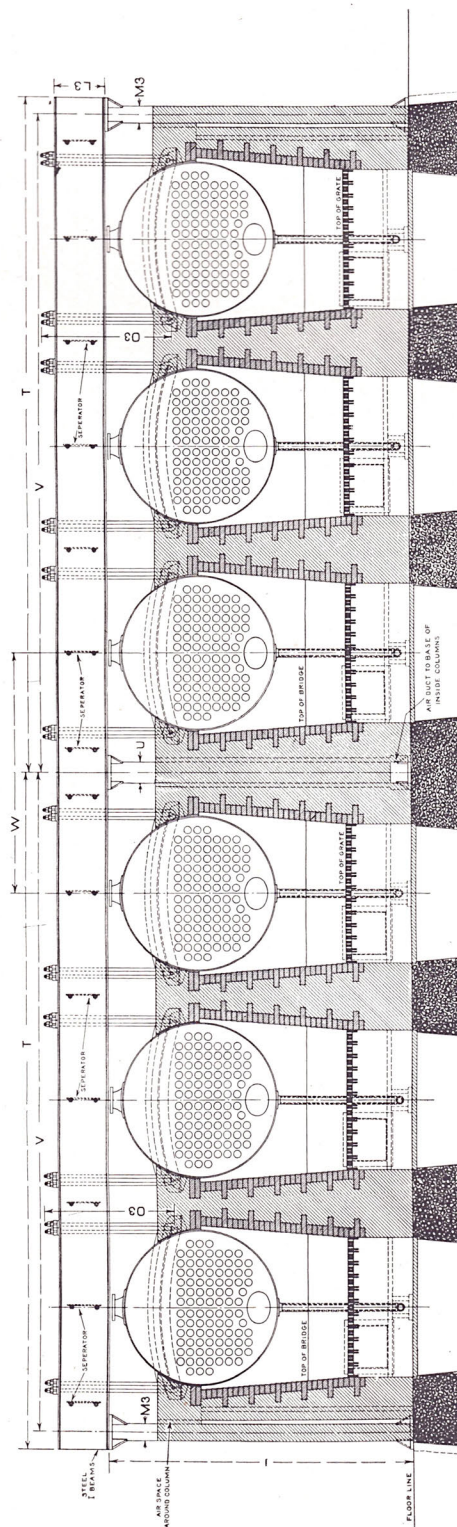
Section of two Horizontal Return Tubular Boilers suspended from I beams resting on outside columns.
See table, page 35



Section of three Horizontal Return Tubular Boilers suspended from I beams resting on outside columns.
See table, page 35



Section of four Horizontal Return Tubular Boilers suspended from I beams resting on outside and center columns. See table, page 35



Section of six Horizontal Return Tubular Boilers suspended from I beams resting on outside and center columns. See table, page 35

MEASUREMENTS FOR SETTING HORIZONTAL RETURN TUBULAR BOILERS SUSPENDED FROM STRUCTURAL WORK

SEE DIAGRAMS FOR THIS TABLE ON THREE PRECEDING PAGES

[illegible]

* Beams for boilers larger than 78" in diameter require special girders.

Length of U bolts will depend on height of special girders.

* Beams for boilers larger than 78" in diameter require special girders.

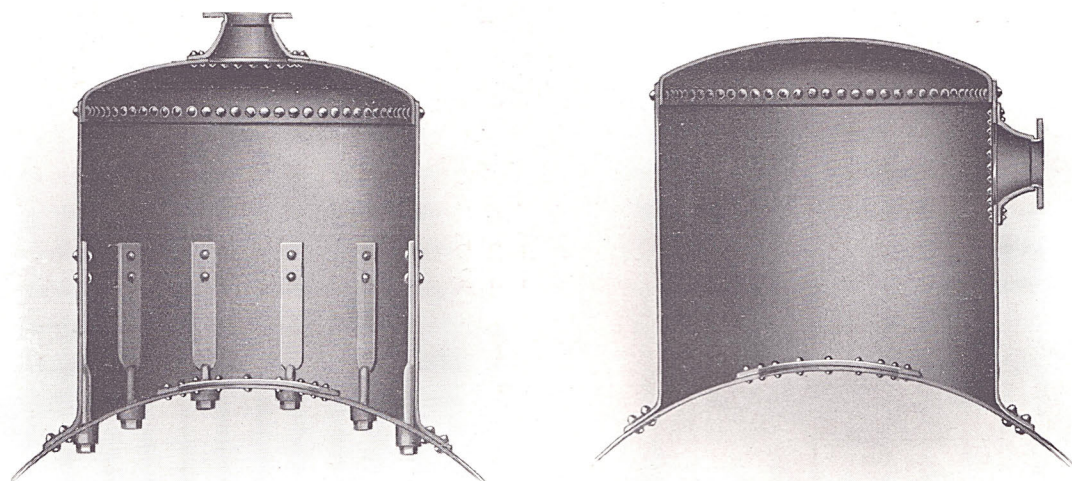


PLATE 31
Illustrating steam dome construction

Component Parts in Pressed Steel

Lugs, hangers, manhole saddles, manhole plates, nozzles and moldings for the fronts of all Bigelow Boilers are now made of pressed steel instead of the cast iron still being used by many manufacturers.

We have been able to effect these remarkable improvements in the quality of parts because we use to the uttermost advantage the most modern improved tools; in particular, a fine range of hydraulic flanging presses.

Little need be said to emphasize the fact that in making these vitally important parts of pressed steel we have produced something far superior to cast iron for strength, durability and appearance. Further reference to the above parts is given in other articles.

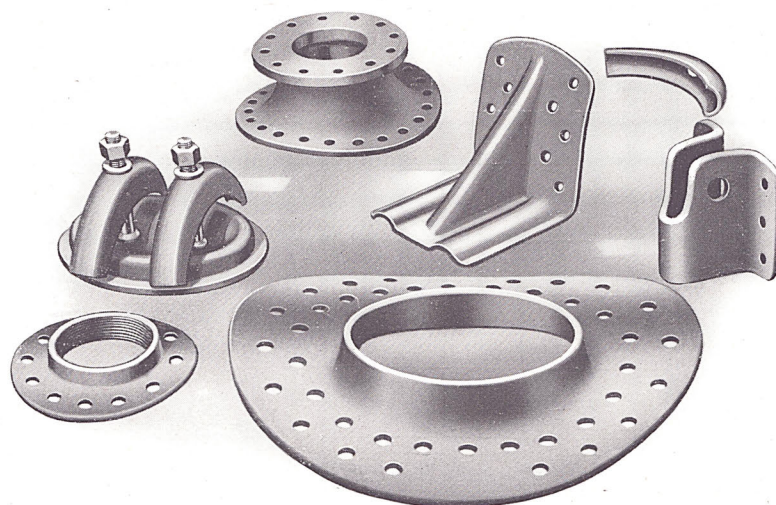


PLATE 32
Illustrating various pressed steel parts as used on our Horizontal Return Tubular Boilers

Grates

Either of three distinct types of stationary grates will be furnished with Bigelow Horizontal Return Tubular Boilers. These are the Herringbone, the Maitland and the Rowley. Any grate may be had in various widths of air spaces and for furnaces of any size. If preferred and specified, we will provide shaking grate with any of our boilers.

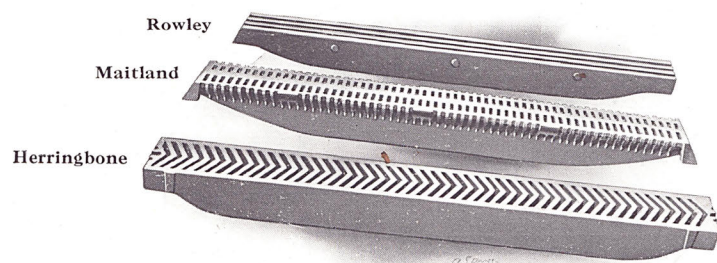


PLATE 33
Illustrating three types of stationary grates

The Bigelow Manning Boiler

The cut on page 39 illustrates very clearly the construction of a Bigelow Manning Boiler as well as being a part sectional view.

The shell portions of the boiler, which are subjected to the greatest stresses, are entirely removed from contact with furnace gases, and the plates can never be subjected to a temperature higher than that of the steam. This type of boiler is practically immune from explosion due to low water or other causes. When the water level reaches a dangerous point, warning is usually given by the collapse of a tube, or if this does not occur (due to a rapid fall of water level, as would result from the opening of a blow-off cock) and the water reaches a point low enough for the crown sheet to be affected, the small amount of water left in the boiler renders an explosion impossible.

The firm support of a boiler is one of the necessary features conducive to safe operation. This is accomplished in the Manning type without relying upon the support of setting walls or expensive structural work. All that is necessary is a firm foundation upon which the cast-iron base may rest. If a brick base is used, there is required about twenty inches of brickwork above the floor line on which is a cast-iron plate. This brickwork is in reality a part of the foundation, and is in no way exposed to the heat from the furnace.

The shell sheets of the Manning Boiler being away from contact with the fire permits the use of any thickness of shell necessary for high pressures. This type of boiler can be constructed suitable for two hundred pounds working pressure or more, in units up to five hundred horse-power. The heat-transmitting surface may be made of practically uniform thicknesses regardless of the size of the boiler.

The early designs of the Manning Boiler had the ogee flange down near the crown sheet and handholes in the barrel of the boiler. This did not permit proper access for cleaning the crown sheet and was soon changed, the handholes being placed on a line with the crown sheet by raising the ogee flange and locating these handholes in the outer sheet of the furnace. We have been among the foremost builders of this type of boiler, and early recognized the importance of being able to properly reach all portions of the crown sheet for cleaning and inspection. We have devised a system of handholes, properly re-enforced, and located around the crown sheet in such a manner that each tube aisle can be reached. Constructed with this cleaning device the Bigelow Manning Boiler may be operated with any reasonably good feed water with entire success and safety if proper care is used in removing deposits of scale-forming matter that tend to collect around the lower ends of the tubes and on the crown sheet. A reference to Plate 36 will readily show the arrangement of these handholes.

Many engineers who have had unsatisfactory experience with the vertical tubular type of boiler, owing to their inability to reach and clean the crown-sheet, have become strongly prejudiced against this type. To such we would say that the Manning Boiler if equipped with the Bigelow cleaning device is as different from the usual construction in regard to accessibility as the open and closed type of feed-water heater.

The tube ends of the Bigelow Manning Boiler are well beaded over on both ends, which preserves the strength of the material in the projecting ends of the tubes,

**Strength of
Boiler**

Base

Plates

**Reverse
Flange**

**Cleaning
Device**

Tubes

**Outside
Furnace**

and tends to prevent the possibility of the crown sheet being pulled away from the tubes from overheating, due to scale deposits or other causes.

The design of the barrel above the ogee flange is the same in this boiler as required for any cylinder of similar diameter for withstanding internal pressure, but the design of the outer furnace shell is not of the same nature. The only portion of this outer furnace shell which requires its thickness to be based on the diameter is the short section above the stay-bolted surface.

**Construction of
Outside Furnace**

The force tending to rupture two cylinders of different diameters which are strongly stayed to each other depends upon the cross-sectional area of the space between them, and is entirely independent of the diameters. Since the area exposed to pressure between the inner and outer sheets of the furnace in the Manning Boiler is relatively small, these sheets along the stay-bolted surface can be made as thin as will admit of proper strength for staying. Since there is no need for great strength to resist rupture, the most serviceable joint is one which can be made tight to prevent leaking; hence single riveted joints are used along this stay-bolted surface. Above the stay-bolted section the diameter becomes a factor in the determination of the strength, and this part is designed along the same lines as the other cylindrical portions of the boiler. It has been customary, on account of the requirement for strength of this upper portion of the outer furnace sheet, to make the entire sheet of suitable thickness for its diameter. This construction imposes rather severe conditions on the stay-bolts, for flexibility is prevented at the outer end of the stay-bolts on account of the thickness of the outer sheet, and this greatly adds to their liability to break at the connection to this thick sheet. We have greatly improved the construction by substituting a thinner outer furnace sheet and re-enforcing the portion above the stay-bolts with a continuous strap, this strap being made integral with the outer furnace sheet by rivets passing through the two plates at frequent intervals.

Furnaces

The principal advantage derived from the ogee construction as used in the Bigelow Manning Boiler is an increased furnace area without a corresponding increase of diameter or weight of the barrel portion of the boiler. This gain in furnace area is of considerable advantage in the large-size boilers. Boilers above three hundred and twenty-five horse-power are generally arranged with a mechanically stoked furnace, which permits practically any ratio between grate and heating surface desired and also admits of increasing the tube lengths to twenty feet.

**Operative
Features**

Every feature leading to economical performance is obtained in the Bigelow Manning Boiler in ideal form. The economical evaporative performance of this boiler is remarkable. It is rarely equaled and cannot be surpassed by any other type in this respect.

In the first place, the uniform distribution of the furnace gases over the heating surface is practically perfect, regardless of the rate of driving, and the importance of this feature alone as contributing to high efficiency under average working conditions can hardly be overestimated. All the surfaces for the transmission of heat are comparatively thin, which contributes to rapid and economical transfer of heat. All the radiant heat from the fuel bed is absorbed directly by water-heating surface. Owing to the short and direct passage of the gas from the furnace to the flue, the friction of the products of combustion through the boiler is greatly reduced, permitting a relatively small tube diameter, practical with ordinary draft conditions. The small diameter of tubes used results in high velocity of the gas over the heating

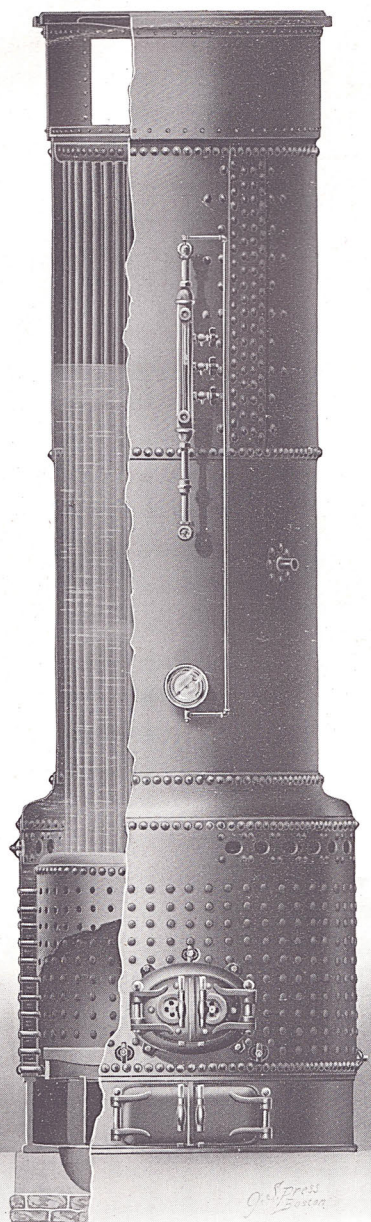


PLATE 34

Illustrating general construction of Manning
Boiler set on independent cast-iron base

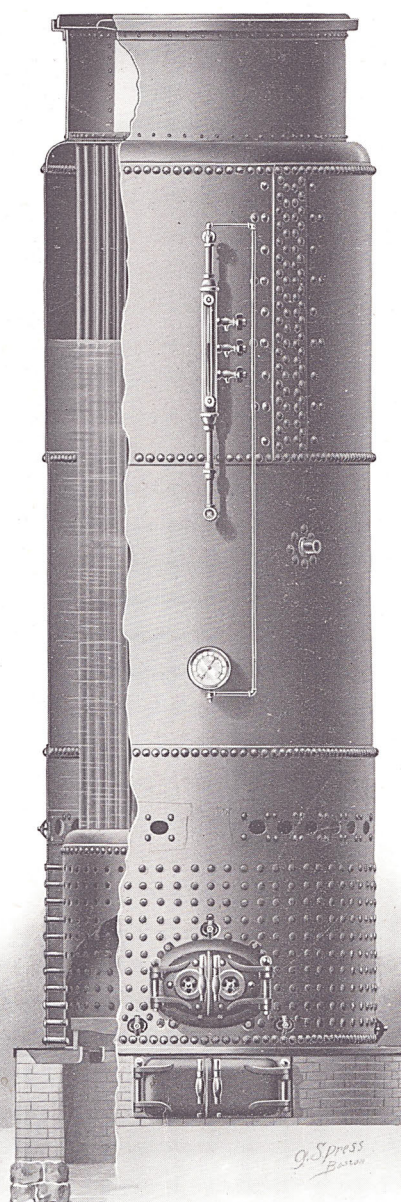


PLATE 35

Illustrating general construction of large straight
shell upright boiler set on flat base

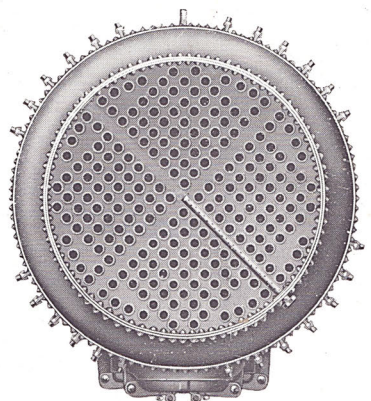


PLATE 36

Illustrating section of plate just above the feed,
showing tube layout and cleaning device

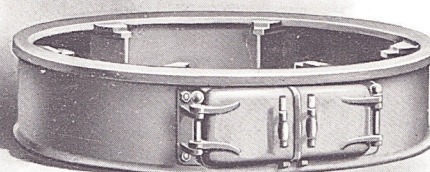


PLATE 37

Illustrating independent cast-iron base such as can
be used on either the Manning or large
straight shell upright boiler

surface, and the most recent investigations relative to boiler performance indicate that this rapid flow contributes greatly toward producing a high rate of heat transfer. Owing to the fact that there are no heavy settings to absorb the heat and that there is comparatively little water contained per square foot of heating surface, the Manning Boiler responds rapidly to changes in furnace conditions, and for the same reasons the stand-by losses are comparatively small. In plants operated only ten or twelve hours a day, as is the usual custom, this feature of low stand-by losses is of considerable moment.

Radiation

In addition to the elimination of all expense necessary for setting repairs the Bigelow Manning Boiler absolutely prevents all losses due to the infiltration of air as occurs in the usual form of brick settings. The only possible manner in which air can reach the heating surface is by way of the grate or firing door. The radiation losses in this boiler are reduced to a minimum.

Superheat

Where the steam generated is to be used for power purposes the strong point of this boiler that produces over-all plant efficiency is that it furnishes superheated steam. The amount of superheat is slightly variable under different conditions, averaging about thirty degrees Fahrenheit when the water level is carried at the customary point (four feet below the upper tube sheet) and the boiler operated near its rated capacity.

The superheat furnished is varied by changing the water level. Lowering the level increases the superheating surface and amount of superheat. A five hundred horse power boiler with tubes twenty feet long and with the water level about seven feet below the upper tube sheet will give approximately fifty degrees superheat when operated at rated capacity. This superheat is obtained without extra first cost.

Space

The Bigelow Manning Boiler occupies per horse-power much less ground space than other types. The space occupied consisting almost entirely of furnace area means that the limit of economy in floor space has been reached in this type of boiler. To indicate that the features which contribute to efficiency actually exist and are by no means imaginary, reference may be made to a series of tests on page 48.

Notwithstanding the fact that the Bigelow Manning Boiler excels in safety of operation, economy of floor space, evaporative efficiency, over-all plant economy, and also supplies superheated steam, it has another point in its favor that is as fully appreciated by the commercial man as by the trained engineer. This is low first cost.

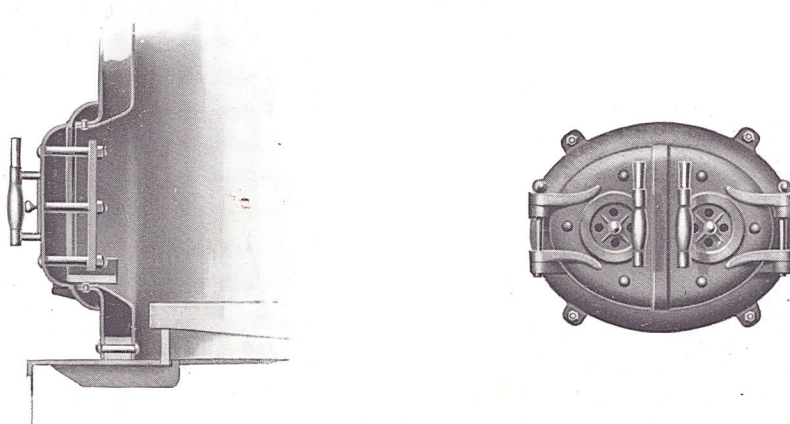


PLATE 38

Illustrating fire door as used on Manning and large straight shell upright boilers

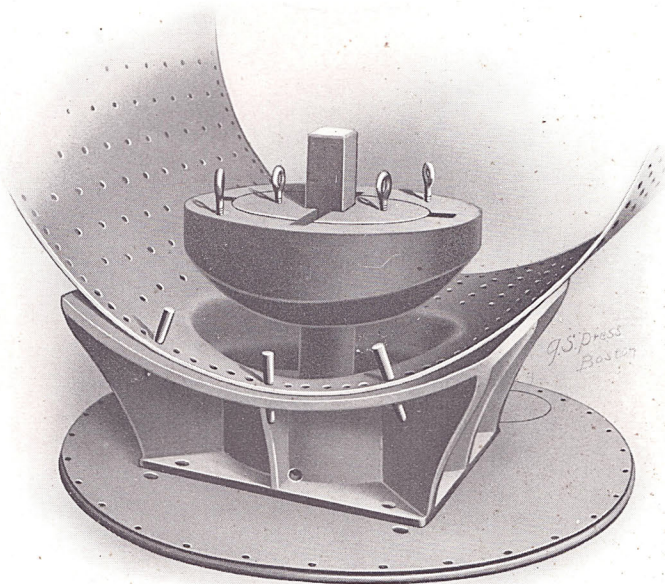


PLATE 39

Illustrating our method of flanging the fire door opening in our Mannings and large, straight shell upright boilers

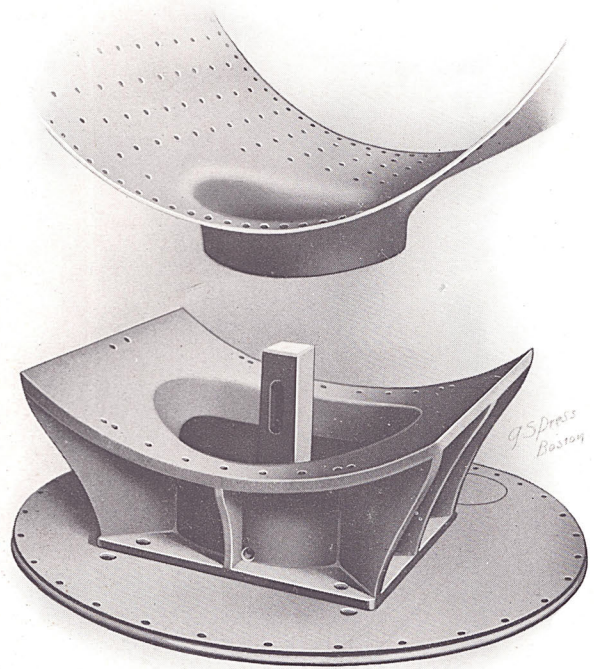


PLATE 40

Illustrating inside furnace sheet just after the door opening has been flanged

Door Construction on Manning Boilers

Plates 39 and 40 show the method of flanging the furnace plates for the fire doors of our Manning Boilers. Plate 38 shows a cross-section of this door when completed.

This method of construction was original with us. It is accomplished by cutting an elliptical hole in the furnace plates, the edges of which are then heated and turned out into position by hydraulic pressure. After the inside and outside furnace plates have been stay-bolted together, the projecting portions forming the door opening are laid up iron to iron, and the rivet holes drilled. These two projecting furnace plates are then riveted together. In this way no rivets around the fire door can come into direct contact with the fire. So that troubles with leaky rivets at this point are entirely eliminated. This is without exception the most successful form of fire door construction extant.

Flanging

Most manufacturers not equipped with hydraulic flangers have, since we have adopted this form of constructing our fire doors, attempted to imitate their construction by flanging out doors by hand. The fact that so many heats have to be taken results in the metal being thinned down to almost one-half the thickness as when done by hydraulic flanging.

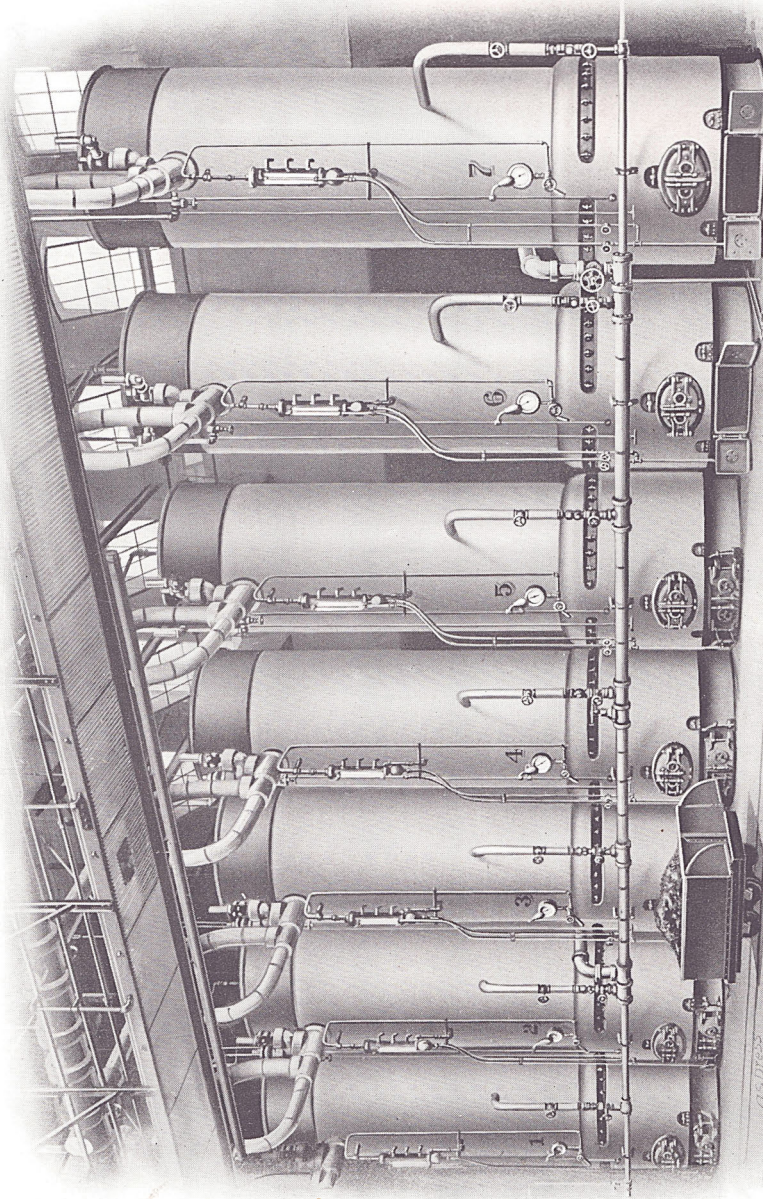


PLATE 41

Illustrating partial battery of eleven 225 horse-power Manning boilers installed at the plant of Landers, Frary & Clark, New Britain, Conn.

Instructions for Setting Bigelow Manning and Straight Shell Vertical Boilers

When a boiler arrives it should be carefully unloaded and transported to the site of erection. One should remember that it is made up of a number of plates riveted together, and that the tightness of each tube depends upon two expanded joints, therefore a boiler should be handled with care.

Unloading

If a brick base with an iron cap (as illustrated in Plate 35) or an independent iron base (like Plates 34 and 37) is used, care must be taken to have the base set firmly and level before placing the boiler in position. With a brick base (like Plate 35) it is most convenient to level the iron cap on the brickwork and pour grout under the cap, allowing the grout and brickwork to set thoroughly before placing the boiler in position.

Setting the Base

When an independent iron base which is faced top and bottom is furnished (like Plate 37) the foundation on which it rests should be made level, and then the top of the base must necessarily be level.

It is more convenient to accurately level the base on the foundation and pour grout under it to make it rest solidly. If the base has been properly set, the boiler when placed upon it should rest firmly in a vertical position. If it shows a tendency to rest on two points, the use of small metal shims of the required thickness will prevent any tendency to rock. With either style of base it is better to provide an ash-pit below the floor level, as illustrated in Plates 34 and 35.

The fire-door frame for each boiler is shipped with the doors in place (as shown in the front view of Plate 38) and the frames and boilers marked so that the correct frame can be placed on the boiler to which it has been fitted. When removing the doors to bolt the frame in position care should be used to see that the doors do not become mixed with others belonging to another frame. In the shop the doors are fitted accurately to suit each frame, and they will not fit properly if used on another frame. After the door frame is bolted in position, the dead plate casting (shown in the sectional view, Plate 38) should be placed in position.

**Fire Doors
and Frames**

Put on the smoke bonnet with the angle iron ring resting on top of the boiler shell. This will leave it free to revolve, so that the opening for connecting to the flue can be turned in any direction desired. Fix the cross pieces accurately and then the cover plates can be placed in position. Place these covers with the ribs on the adjacent edges turned up; those on the curved ends projecting downward into the groove formed by the "Z" bar and end of bonnet shell at the outer edge.

Smoke Bonnet

When the tubes of a boiler are from twelve to eighteen feet in length the water column should be located so that the working level, or say the second gauge cock, is about four feet below the top tube sheet.

**Location of
Water Column**

Before shipment all boilers are carefully inspected and loose bolts and nuts, etc., that may have been left in after construction, removed. But dirt and various objects are liable to get into a boiler during shipment. Before closing the handholes, therefore, the interior should be carefully examined and cleared of all loose material. When a boiler is provided with the Bigelow patent cleaning device (consisting of a series of handholes on a level with the crown sheet—see Plate 36) practically every portion of this surface can be seen and reached for the purpose of cleaning.

**Cleaning Out and
Starting Boilers**

This is evident from Plate 36, which shows the relative position of tube aisles and handholes in sectional plan. In the manufacture of boilers the interior surfaces are liable to collect a certain amount of grease, oil and dirt that washing cannot remove, which on starting up new boilers is often the cause of foaming. To avoid this, dissolve about fifty or sixty pounds of soda ash for each one hundred boiler horse-power and pump it in at the first filling up, after which a slow fire should be kept under the boiler for a day or two, then allowed to cool. After emptying the boiler, all the handhole plates should be removed and the interior surfaces thoroughly washed off with a strong stream of water from a hose. Unless this washing is done thoroughly, the soapy residue formed by the mixture of oil and soda ash will still remain on the tubes and shell and be likely to cause foaming.

**Laying up
Boilers**

Care must be exercised in laying up a boiler for long idleness, otherwise it will deteriorate more rapidly than when in use. To properly prepare a boiler for idleness, it should be thoroughly cleaned, both externally and internally, sweeping off all soot and ashes from the tubes and plates. All openings should be left open to allow as free a circulation of air as possible. A boiler should never be laid up with water in it, for this will cause very rapid external corrosion, due to sweating.

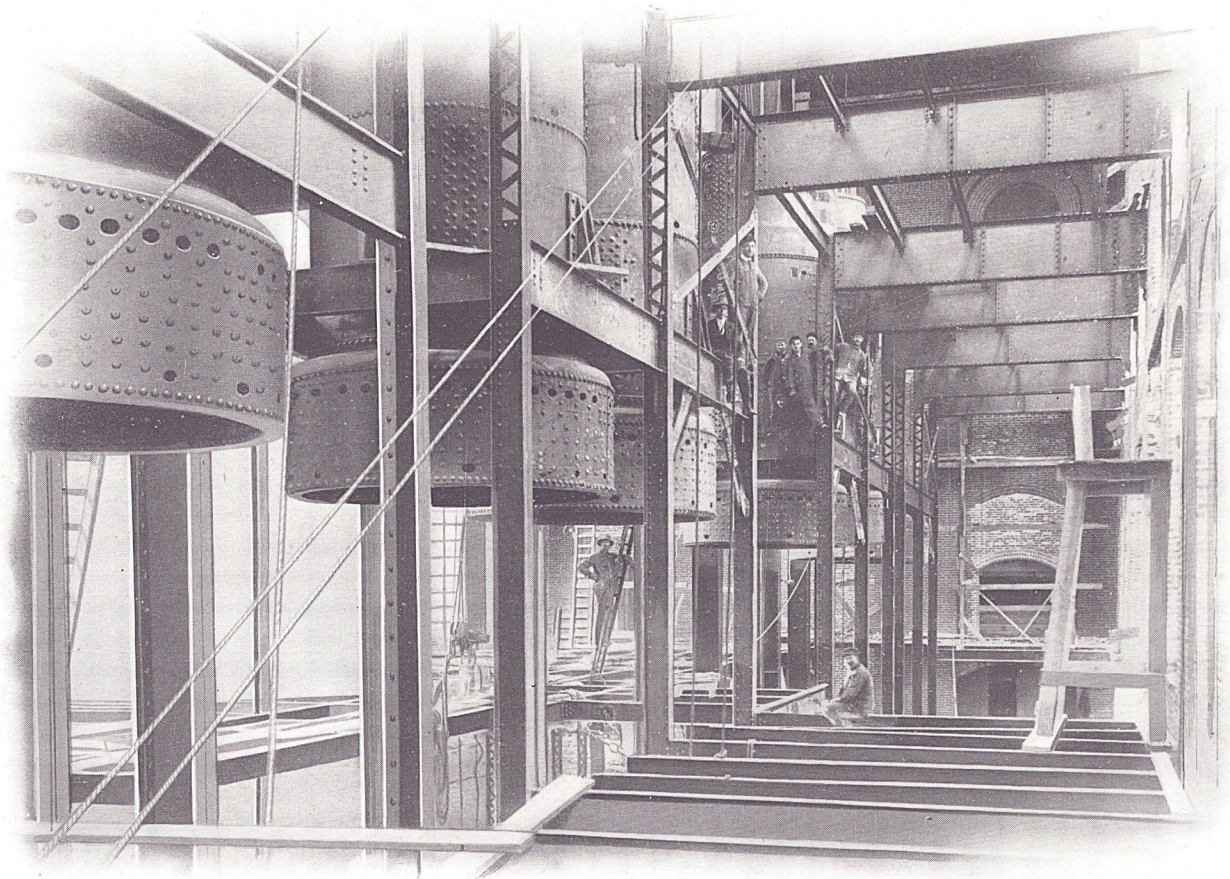


PLATE 42

Illustrating partial battery of sixteen 500 horse-power Manning boilers in the course of erection at Arlington Mills, Lawrence, Mass., under which are installed eight Roney type of stokers and eight Taylor type of stokers

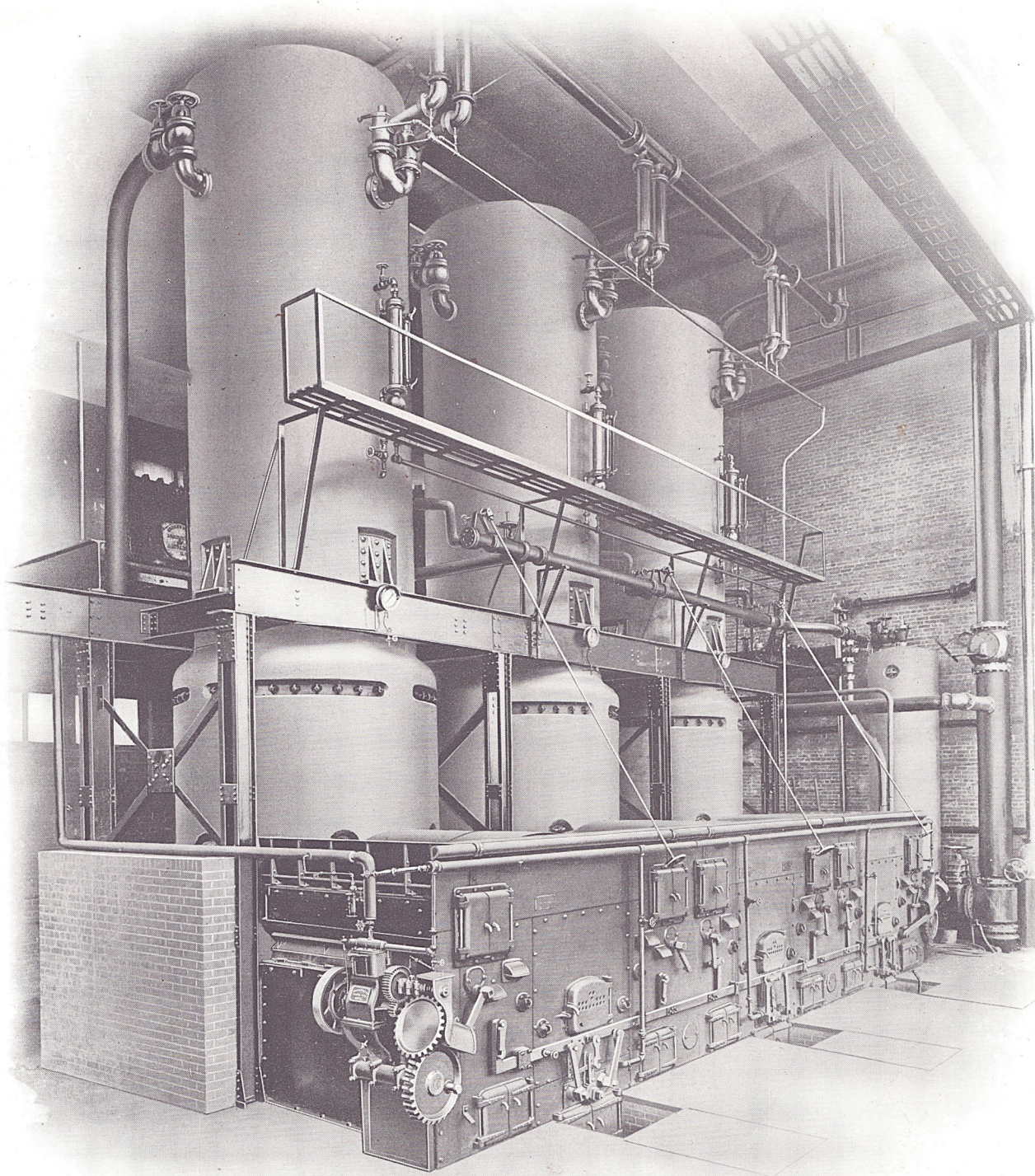
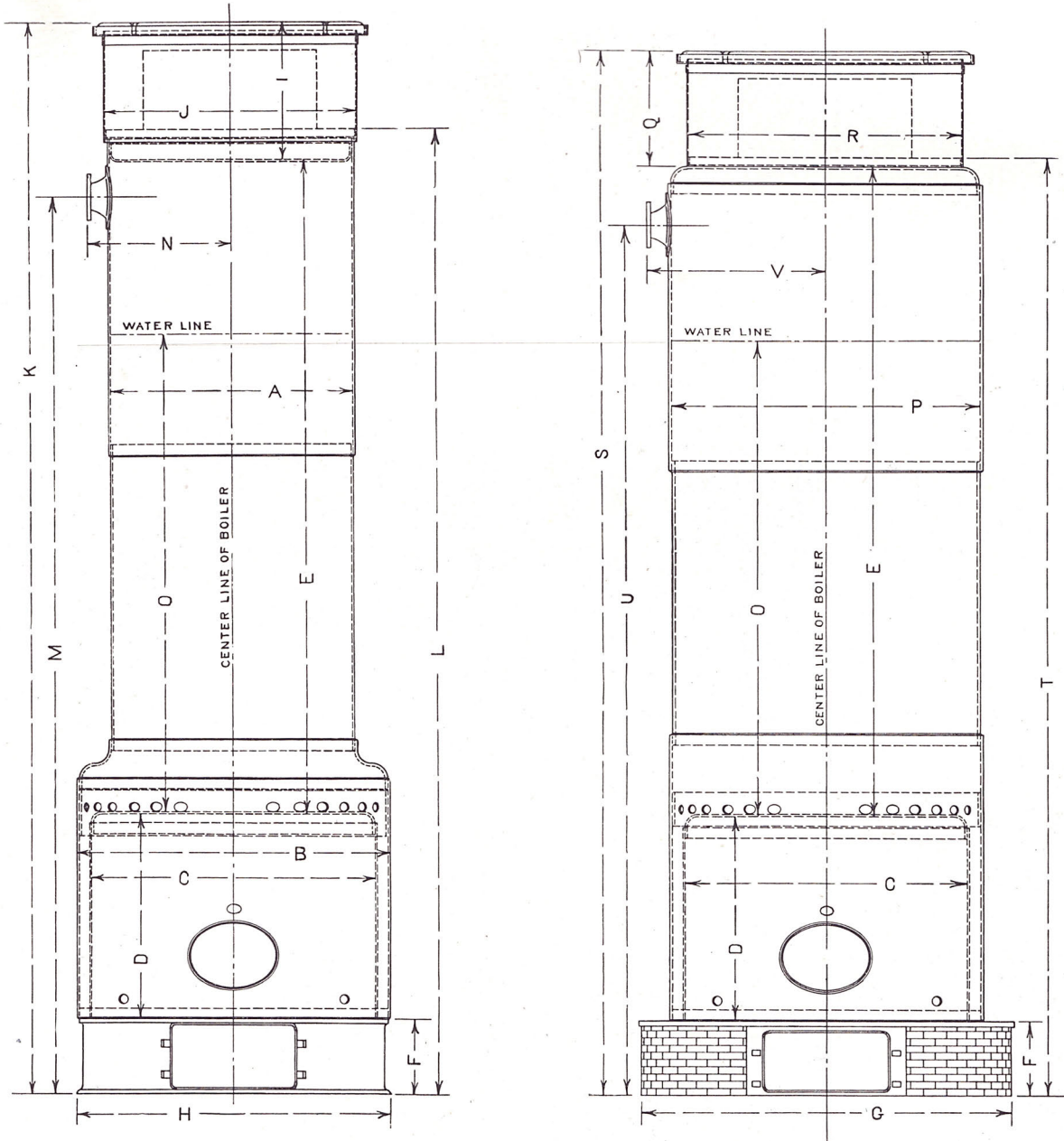


PLATE 43

Illustrating three 260 horse-power Manning Boilers set with Murphy Stokers at the Bridgeport Malleable Iron Co., Bridgeport, Conn.



Line drawings of the Manning and large straight shell upright boilers. Table given on page 47 will enable one to determine the principal dimensions of the various size units. Any dimensions that are not given and that are desired will be furnished upon request

GENERAL DIMENSIONS OF MANNING AND LARGE UPRIGHT BOILERS

RATING AND HEATING SURFACE				BARREL AND FURNACE				TUBES		BASE			BONNET			MISCELLANEOUS																			
Number of Boiler	* Horse-power Based on 12 Sq. Ft. of Total Heating Surface	* Total Heating Surface	* Water Heating Surface	* Superheating Surface	* Additional Heating Surface for Each Foot of Tubes	A	B	C	D	* Tubes		F	G	H	I	J	* Bonnet		Floor Line to Top of Bonnet	Floor Line to Under Side of Smoke Opening	L	M	N	O	* Height of Water Line from Crown Sheet	* Size of Steam Nozzle	* Size of Feed Pipe	* Size of Blow-off Pipe	* Number of Fire Doors	* Number of Handholes in Bigelow Patent Cleaning Device	Diameter of Stack Required	* Height of Stack Required	* Number of Common Brick Necessary to Construct Brick Setting for Plate above Floor Line	* Distance from Center to Center of Boilers when set in Battery	
						Diameter of Barrel or Waist	Outside Diameter of Outside Furnace Plate for 175 lbs. Pressure	* Inside Diameter of Inside Furnace Plate	* Height of Furnace	* Diameter of Tubes	* Number of Tubes	* Length of Tubes	* Height of Base	* Outside Diameter of Brick Base	* Outside Diameter of Cast-iron Base at Bottom of Flange	Height of Bonnet from Upper	Diameter of Bonnet	Size of Smoke Opening in Bonnet																	Floor Line to Center of Steam Nozzle	Center Line of Boiler to Face of Steam Nozzle on Boiler for 175 lbs. Pressure
1	45	522	415	107	42.5	38	55%	48	42	2	90	19 1/2	5	4	4 1/2	2	43	12 x 20	18	8	17	15	15 1/2	8	6	4	4	1 1/4	1	15	24	60	525	5	6
2	63	745	574	171	52.6	44	61%	54	42	2 1/2	88	19 1/2	6	6	5 1/2	4	49	16 x 24	21	0	19	17	17 1/2	9	9	4	4	1 1/4	1	18	27	60	575	6	4
3	80	1061	793	268	57.7	48	65%	58	44	2 1/2	112	19 1/2	6	6	5 1/2	5	53	18 x 28	23	4	21	19	19 1/2	11	0	4	4	1 1/2	1	18	30	70	610	6	4
4	100	1182	882	394	61	56	67 3/8	66	44	2 1/2	124	19 1/2	7	6	5 1/2	1	60 1/2	18 x 30	23	4 1/2	21	19	19 1/2	11	0	4	4	1 1/2	1	22	33	70	630	6	6
5	120	1446	1087	450	64.9	61	73 1/8	72	44	2 1/2	156	19 1/2	8	6	5 1/2	11	64	20 x 36	24	5 1/2	21	19	19 1/2	11	0	5	5	1 1/2	1	22	33	70	680	7	6
6	132	1594	1247	555	67.6	67	80	72	56	2 1/2	188	19 1/2	8	6	6 1/2	11	64	20 x 36	24	5 1/2	21	19	19 1/2	11	0	5	5	1 1/2	1	25	36	75	735	8	0
7	152	1882	1647	680	71.3	67	86	72	56	2 1/2	232	19 1/2	9	6	6 1/2	11	70	22 x 42	24	5 1/2	22	20	20 1/2	11	0	6	6	1 1/2	1	25	36	75	785	8	0
8	182	2261	2001	807	76.6	76	92	84	60	2 1/2	284	19 1/2	9	6	7 1/2	3	79	24 x 48	24	10 1/2	22	20	20 1/2	12	0	6	6	2 1/8	1	28	42	80	840	9	6
9	225	2681	2548	997	80.1	80	98	90	66	2 1/2	332	19 1/2	9	6	8 1/2	3	83 1/2	24 x 52	26	4 3/4	23	22	21 1/2	12	0	7	7	2 1/8	1	32	45	80	890	9	6
10	275	3345	2975	1195	83.6	86	104	96	66	2 1/2	382	19 1/2	10	6	8 1/2	5 1/4	88	26 x 58	26	6 3/4	23	22	21 1/2	12	0	7	7	2 1/8	2	34	48	90	940	10	8
11	380	4548	3457	1691	92	92	110	102	66	2 1/2	456	19 1/2	10	6	9 1/2	7 1/4	93 1/2	28 x 68	26	8 1/2	23	22	21 1/2	12	0	7	7	2 1/8	2	38	50	1000	10	8	
12	415	4971	3776	1195	95	98	116%	108	66	2 1/2	500	19 1/2	11	0	9 1/2	9 1/4	100	30 x 78	26	10 3/4	23	22	21 1/2	12	0	7	7	2 1/8	2	41	52	100	1050	11	4

STRAIGHT SHELL UPRIGHT BOILERS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
Number of Boiler	150 Lbs. Pressure				175 Lbs. Pressure				200 Lbs. Pressure				WEIGHT		Diameter of Bonnet	Height of Bonnet	P	Q	R	S	T	U	V	Weight of Boiler Complete with all Castings and Trimings																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
	Barrel	* Outside Furnace Plate also Re-enforcing Sheet above Crown Sheet	* Heads	Reverse Flange	Barrel	* Outside Furnace Plate also Re-enforcing Sheet above Crown Sheet	* Heads	Reverse Flange	* Inside Furnace Plate for all Pressures	Weight of Boiler Complete with all Castings and Trimings	* Additional Weight with Cast-iron Base	† Thickness of Barrel for 150 lbs. Pressure	† Thickness of Barrel for 175 lbs. Pressure	† Thickness of Barrel for 200 lbs. Pressure																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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* Apply to both Manning and upright boilers

† Thickness of material figured on a basis of 57,000 lbs. tensile strength and a factor of safety of 5

THE BIGELOW COMPANY, NEW HAVEN, CONNECTICUT

Performance of Battery of Bigelow Co.'s Manning Boilers at Bristol Mfg. Corporation, New Bedford, Mass.

By J. E. DENTON, Professor of Experimental Mechanics, Stevens Institute of Technology.

Dimensions of each Boiler

Diameter of shell.....	5 feet
Diameter of fire box.....	6 feet
Height of fire box.....	3 feet 6 inches
Number of tubes.....	180
Diameter of tubes.....	2½ inches
Length of tubes.....	15 feet
Grate surface.....	28.7 feet
Water heating surface with 16 inches of water in glass.....	1,383 square feet
Superheating surface with 16 inches of water in glass.....	471 square feet
Ratio of water heating surface to grate.....	48.2
Ratio of superheating surface to grate.....	16.4
Ratio of grate to cross-section of tubes.....	4.4
Percentage of air space in grates.....	40%
Grates.....	Ordinary "fixed-bar" type
Ratio of grate to ash-pit opening.....	9.4
Height of chimney.....	160 feet
Internal diameter of chimney.....	6 feet
Boilers thickly covered with non-conducting plaster	

	1	2	3	4	5	6
2 Number of boilers in use.....	4 to 9 (6)	4 to 9 (6)	4 to 9 (6)	2 to 7 (6)	2 to 9 (8)	3 to 9 (7)
3 Kind of coal.....	Pocahontas Bituminous	Pocahontas Bituminous	Pocahontas Bituminous	Pocahontas Bituminous	Pocahontas Bituminous	Pocahontas Bituminous
4 Duration of test.....	9 hr. 41 m.	9 hr. 39 m.	9 hr. 12 m.	8 hr. 37 m.	8 hr. 39 m.	8 hr. 39 m.
5 Average pressure above atmosphere, lbs.....	124.3	125.1	124.7	148.9	124.2	125.5
6 Average water level, ins.....	11.1	9.51	9.84	10.77	10.34	10.79
7 Average feed temperature, degrees F.....	159.7	150.75	158.5	169.1	163.27	166.45
8 Average steam temperature, degrees F.....	369.5	371.8	372.4	378.0	368.7	370.75
9 Average degrees superheating at middle of steam main.....	17.1	19.0	19.8	12.9	16.5	17.7
10 Average flue temperature, degrees F.....	478.0	510.5	492.5	470.0	467.0	460.0
11 Total coal consumed, lbs.....	20,189	22,439	21,510	18,589	20,382	18,748
12 Percentage of moisture in coal.....	4.75	4.75	4.75	4.75	4.75	4.75
13 Total ashes, lbs.....	1,682	1,869	1,792	1,549	1,699	1,562
14 Percentage of ashes.....	8.33	8.33	8.33	8.33	8.33	8.33
15 Total combustible, neglecting water, lbs.....	18,507	20,560	19,718	17,041	18,683	17,186
16 Total combustible, deducting water, lbs.....	18,031	19,749	19,058	16,158	17,716	16,396
17 Total heat per pound of combustible by oxygen calorimeter.....	15,398	15,398	15,398	15,398	15,398	15,398
18 Total water evaporated, lbs. (measured by meter).....	210,399	228,798	217,299	189,416	215,895	192,877
19 Water actually evaporated per hour, lbs.....	21,735	23,710	23,619	21,923	24,959	22,428
20 Equivalent water evaporated from and at 212° F. per hour, lbs.....	24,039	26,484	26,194	24,071	27,505	24,670
21 Equivalent water evaporated per sq. ft. of heating surface per hour from and at 212° F., lbs.....	2.90	3.19	3.16	2.90	2.48	2.55
22 Equivalent H.-P. per boiler: 1 H.-P. = 34.5 lbs. per hr. from and at 212°.....	116.1	124.5	126.5	116.3	99.7	102.2
23 Equivalent H.-P. for Corliss compound engines: 1 H.-P. = 14 lbs. per hour at actual pressure and 200° feed temperature.....	264.4	295.7	299	268.4	230.5	236.0
24 Coal per hour, lbs.....	2,086	2,325	2,338	2,157	2,356	2,180
25 Coal per hour per sq. ft. of grate, lbs.....	12.30	13.71	13.78	12.72	10.42	11.01
26 Water actually evaporated per lb. coal, lbs.....	10.42	10.19	10.10	10.12	10.59	10.29
27 Equivalent water evaporated from 212° F. at actual pressure and with actual superheating, lbs.....	10.95	10.80	10.64	10.54	11.09	10.75
28 Equivalent water evaporated from and at 212° per lb. of combustible, allowing for moisture, lbs.....	12.90	13.09	12.64	12.77	13.41	13.02
29 Possible evaporation per lb. of combustible from and at 212° by oxygen calorimeter tests, lbs.....	13.38	13.20	13.20	13.41	13.41	13.43
30 Boiler efficiency calculated from lines 17 and 28, per cent.....	80.9	82.1	79.2	80.0	84.1	81.6

Performance of Single Manning Boilers, No. 1 of Battery of nine, at Bristol Mfg. Corporation, New Bedford, Mass.

	1	2	3	4
2 Kind of coal.....	Pocahontas Bituminous	Pocahontas Bituminous	Pocahontas Bituminous	Anthracite Large Pea
3 Duration of test.....	9 hr. 55 m.	9 hr. 45 m.	9 hr. 57 m.	10 hr. 21 m.
4 Average pressure above atmosphere, lbs.....	122.2	122.85	155.7	136.8
5 Average water level, ins.....	14.4	16.9	18.0	14.38
6 Average feed temperature, degrees F.....	38.1	40.1	40.67	43.0
7 Average steam temperature, degrees F.....	379.1	371.1	390.0	378.0
8 Average degrees superheating at safety valve, F.....	28.0	19.6	21.6	18.9
9 Average flue temperature, degrees F.....	531.4	495.9	477.0	420.5
10 Total wood consumed, lbs.....	150	150	94	200
11 Total coal consumed, including 0.4 wood, lbs.....	6,460	4,060	3,060	3,190
12 Percentage of moisture in coal.....	4.75	4.75	4.75	1.0
13 Total ashes, lbs.....	616	417	362	517
14 Percentage of ashes, neglecting wood.....	9.63	10.43	11.97	16.62
15 Total combustible, neglecting water, lbs.....	5,844	3,643	2,698	2,674
16 Total combustible, deducting water, lbs.....	5,566	3,470	2,570	2,642
17 Total heat per pound of combustible by oxygen calorimeter.....	15,398	15,398	15,398	14,302
18 Total water evaporated, lbs. (measured by weighing).....	53,072	34,408	26,477	24,948
19 Water actually evaporated per hour, lbs.....	5,352	3,536	2,661	2,410
20 Equivalent water evaporated from and at 212° F. per hour, lbs.....	6,679	4,353	3,292	2,965
21 Equivalent water evaporated per sq. ft. of heating surface per hour from and at 212° F., lbs.....	4.9	3.1	2.3	2.1
22 Equivalent horse-power: 1 H.-P. = 34.5 lbs. per hour from and at 212° F.....	193.6	126.2	95.4	85.93
23 Equivalent horse-power for compound Corliss engines: 1 H.-P. = 14 lbs. per hour at actual pressure and 200° feed temperature.....	446	299	219	198
24 Coal per hour including wood at 0.4, lbs.....	651	416	308	308
25 Coal per hour per sq. ft. of grate, lbs.....	23.0	14.7	10.9	10.9
26 Water actually evaporated per lb. coal, lbs.....	8.22	8.49	8.65	7.82
27 Equivalent water evaporated from 212° F. at actual pressure with actual superheating, lbs.....	9.61	9.92	10.04	9.13
28 Equivalent water evaporated from and at 212° per lb. of combustible, allowing for moisture, lbs.....	12.00	12.32	12.35	11.61
29 Possible evaporation per lb. of combustible from and at 212° by oxygen calorimeter tests, lbs.....	13.38	13.2	13.01	12.32
30 Boiler efficiency calculated from lines 17 and 28, per cent.....	75.2	77.2	77.4	78.3

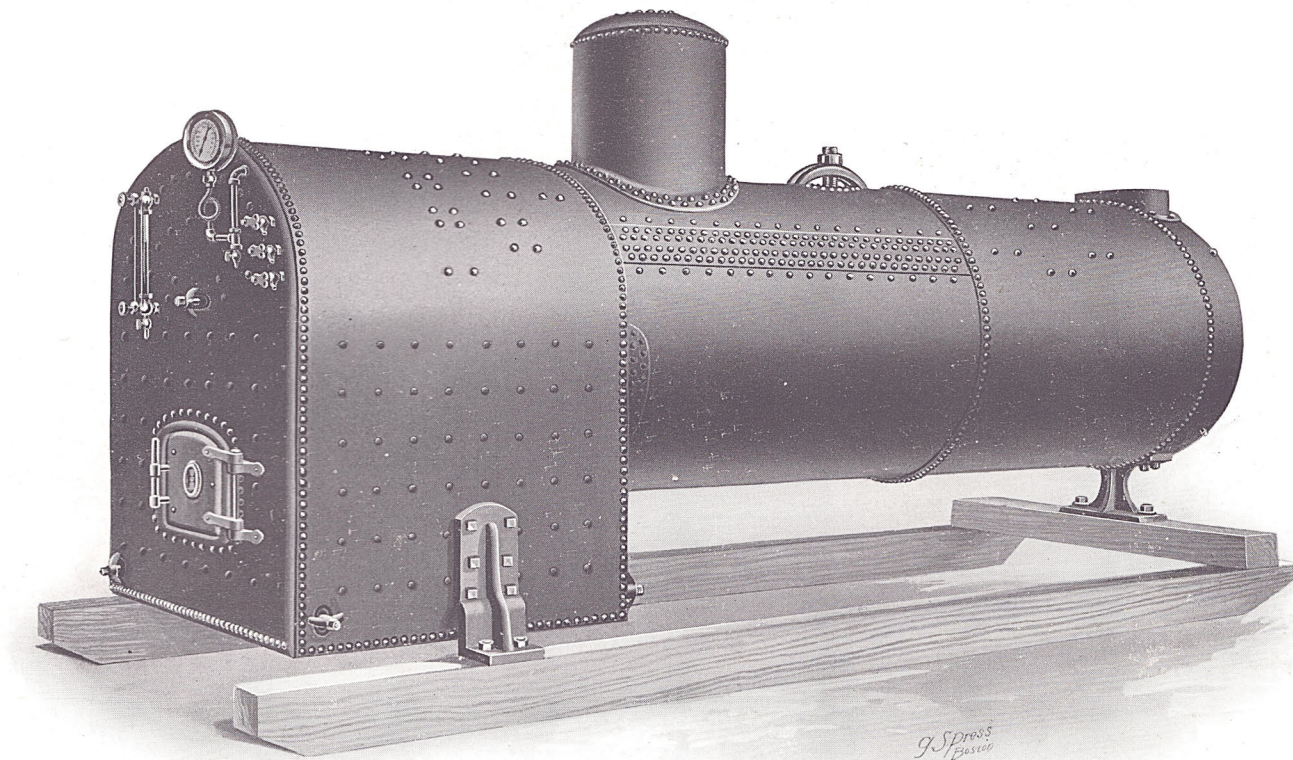


PLATE 44
Illustrating locomotive type of boiler mounted on skids

Locomotive Boilers

The arrangement of the tubes for a locomotive boiler is similar to the Horizontal Return Tubular Boilers, thereby obtaining a large heating surface required by the high rate of combustion. The boiler may be worked under a strong forced draught, produced by throwing the exhaust up the smokestack.

The locomotive boiler (illustrated by Plate 44) may be mounted either on wheels or on skids. If skids are employed the following accessories are furnished: brackets, skids, ash-pan, grate bars, safety valve, steam gauge, glass water gauge and gauge cocks.

The dome of the locomotive boiler is similar in construction to the Horizontal Return Tubular Boiler, as per Plate 31; but is not figured unless specified.

Mounting

Dome

SPECIFICATIONS FOR LOCOMOTIVE BOILERS

Horse-power	Heating Surface in Sq. Ft.	Diameter of Waist in Inches	Width of Furnace in Inches	Height of Furnace in Inches	Length of Furnace in Inches	Thickness of Shell and Front Plate	Thickness of Front, Sides and Top of Furnace	Thickness of Both Tube Sheets	Number of Tubes 3" in Diameter	Length of Tubes in Inches	Diameter of Dome in Inches	Height of Dome in Inches	Diameter of Stack Required in Inches	Length of Boiler over all in Feet	Height of Boiler from Bottom of Skids to Top of Dome	Weight of Boiler without Fixtures	Weight of Boiler Complete with Fixtures
25	253	40	34	39	48	$\frac{1}{16}$	$\frac{3}{16}$	$\frac{3}{8}$	34	96	24	24	16	14	87	6,600	7,500
30	306	42	36	40	50	$\frac{1}{16}$	$\frac{3}{16}$	$\frac{3}{8}$	40	102	24	24	18	14 $\frac{5}{8}$	90	7,400	8,350
35	350	44	38	44	50	$\frac{1}{16}$	$\frac{3}{16}$	$\frac{3}{8}$	44	108	24	24	19	15 $\frac{1}{2}$	92	8,000	8,975
40	401	44	38	44	50	$\frac{1}{16}$	$\frac{3}{16}$	$\frac{3}{8}$	44	126	24	24	19	16 $\frac{3}{8}$	92	8,600	9,575
50	500	48	42	48	54	$\frac{1}{16}$	$\frac{3}{16}$	$\frac{3}{8}$	55	126	24	24	21	17 $\frac{1}{2}$	101	9,300	10,500
60	600	54	48	50	60	$\frac{1}{16}$	$\frac{3}{16}$	$\frac{3}{8}$	60	144	30	30	22	19 $\frac{1}{2}$	111	11,700	13,100
70	718	56	50	52	60	$\frac{1}{16}$	$\frac{3}{16}$	$\frac{3}{8}$	60	156	30	30	23	20 $\frac{1}{2}$	112	13,600	15,100
80	819	58	52	54	60	$\frac{1}{16}$	$\frac{3}{16}$	$\frac{3}{8}$	76	156	30	30	25	20 $\frac{3}{4}$	117	14,600	16,400
90	912	60	54	54	60	$\frac{1}{16}$	$\frac{3}{16}$	$\frac{3}{8}$	82	162	30	30	26	21 $\frac{1}{2}$	118	15,800	17,700
100	1,022	62	56	56	60	$\frac{3}{8}$	$\frac{1}{16}$	$\frac{1}{2}$	90	168	30	36	28	22 $\frac{1}{4}$	127	16,500	18,500
110	1,133	66	60	60	60	$\frac{3}{8}$	$\frac{1}{16}$	$\frac{1}{2}$	104	162	30	36	30	21 $\frac{3}{4}$	132	17,400	20,300
125	1,243	66	60	60	60	$\frac{3}{8}$	$\frac{1}{16}$	$\frac{1}{2}$	104	180	30	36	30	23 $\frac{1}{4}$	132	18,000	21,200
150	1,525	72	66	62	60	$\frac{3}{8}$	$\frac{1}{16}$	$\frac{1}{2}$	128	180	36	36	34	23 $\frac{1}{4}$	138	20,800	25,000

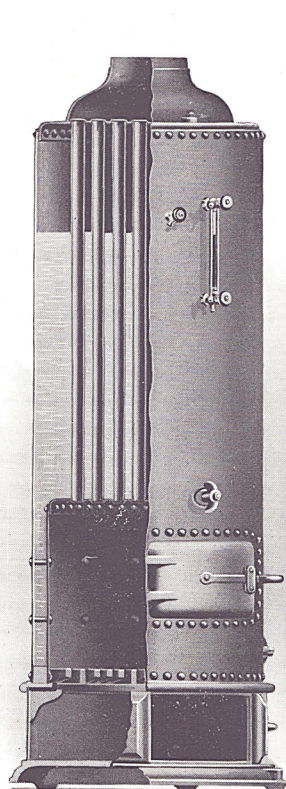


PLATE 45

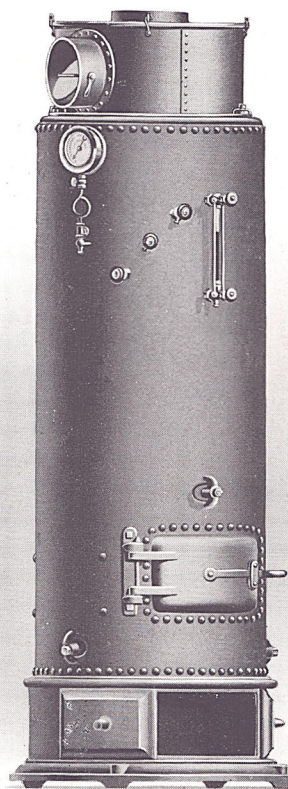


PLATE 46

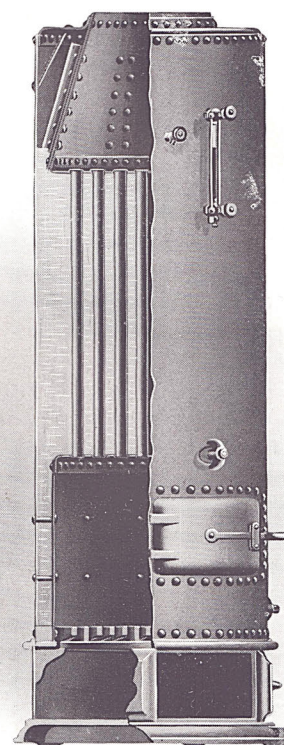


PLATE 47

Illustrating small upright boilers. For dimensions see page 51

Small Upright Boilers

In the construction of our small upright boilers the Bigelow standard of material and workmanship is maintained. These boilers, as is shown by the accompanying table, range from three horse-power to one hundred horse-power, although intermediate sizes will be figured upon if desired. The boilers, as a standard, are constructed for one hundred pounds working pressure from three horse-power up to and including thirty-five horse-power. Above this, one hundred and twenty-five pounds working pressure has been adopted for the standard, although any desired working pressure will be figured on any size boiler.

All castings are extra heavy, in fact no manufacturer provides castings as heavy as ours. In the regular equipment for a boiler the castings consist of ash door, fire door, base, grates and grate ring. The trimmings include safety valve, steam gauge, water gauge and gauge cocks.

The vertical shell seam of all boilers fifteen horse-power and above is of the double strap and butt type joint, and below fifteen horse-power double riveted lap joint.

A wrought-iron cheese-box bonnet as shown on Plate 46, or a cast-iron bonnet as shown on Plate 45, can be furnished with boilers up to and including thirty-five horse-power. Above this horse-power the wrought-iron cheese-box bonnet is regularly furnished.

The leg rings of all boilers from twelve horse-power and upwards are of wrought iron. The door rings are made of wrought iron, from twelve to fifty horse-power. Above this size a flanged fire door (as used in the construction of our Manning boilers) is used. See illustration and description on page 41.

THE BIGELOW COMPANY, NEW HAVEN, CONNECTICUT

SPECIFICATIONS OF REGULAR UPRIGHT BOILERS

Horse-Power Based on 9 Sq. Ft. of Water Heating Surface	Water Heating Surface	Superheating Surface	Total Heating Surface	Outside Diameter of Boiler	Height of Boiler from Bottom of Base to Top of Cheese-Box Bonnet	Height of Boiler from Bottom of Leg Ring to Top Head	Height of Base	Height of Cheese-Box Bonnet	Inside Diameter of Furnace	Height of Furnace	Length of Tubes 2 Inches in Diameter	Number of Tubes 2 Inches in Diameter	Diameter of Bottom of Base	Diameter of Smoke Opening Required	Thickness of Shell	Thickness of Furnace	Thickness of Head	Weight of Bare Boiler	Weight of Boiler Complete with Castings and Trimmings	Size of Steam Outlet	Size of Safety Valve	Size of Blow-off Opening	Size of Feed Pipe
	Sq. Ft.	Sq. Ft.	Sq. Ft.	In.	Ft. In.	Ft. In.	In.	In.	In.	In.	Ft. In.		In.	In.	In.	In.	In.	Lbs.	Lbs.	In.	In.	In.	In.
3	28	15	43	21	6 10	5 0	11	11	16	24	3 0	20	27	7	1/4	1/4	1/4	750	1,050	1 3/4	1	1 1/2	1 1/2
4	40	18	58	24	6 11	5 0	11	12	19	24	3 0	31	31	8	1/4	1/4	1/4	900	1,300	1	1	1 1/2	1 1/2
5	50	22	72	27	7 2	5 0	13	13	22	24	3 0	39	35	9	1/4	1/4	1/4	1,100	1,525	1 1/4	1 1/4	1 1/2	1 1/2
6	59	30	89	30	7 3	5 0	13	14	25	24	3 0	46	37	10	1/4	1/4	1/4	1,300	1,800	1 1/4	1 1/4	1 1/2	1 1/2
8	74	32	106	30	8 4	6 0	13	15	25	24	4 0	46	37	11	1/4	1/4	1/4	1,450	1,950	1 1/4	1 1/4	1 1/2	1 1/2
10	98	40	138	34	8 11	6 6	13	16	28	24	4 6	56	41	12	1/4	1/4	1/4	1,750	2,400	1 1/2	1 1/2	1 1/2	1 1/2
12	121	51	172	36	9 7	7 0	13	18	30	24	5 0	64	43	14	1/4	1/4	1/4	2,100	2,800	1 1/2	1 1/2	1 1/2	1 1/2
15	144	59	203	40	10 2	7 6	13	19	34	30	5 0	74	47	15	1/4	1/4	1/4	2,600	3,500	1 1/2	1 1/2	1 1/2	1 1/2
18	160	66	226	40	10 3	7 6	13	20	34	30	5 0	84	47	16	1/4	1/4	1/4	2,700	3,600	2	2	1 1/2	1 1/2
20	198	54	252	44	10 10	8 0	13	21	38	30	5 6	96	50	17	1/4	1/4	1/4	3,500	4,500	2	2	1 1/2	1 1/2
25	243	105	348	48	10 11	8 0	13	22	42	30	5 6	120	54	18	1/4	1/4	1/4	4,000	5,050	2	2	1 1/2	1 1/2
30	277	122	399	48	11 0	8 0	13	23	42	30	5 6	136	54	19	1/4	1/4	1/4	4,250	5,300	2 1/2	2 1/2	1 1/2	1 1/2
35	322	144	466	48	12 1	9 0	13	24	42	30	6 6	140	54	20	1/4	1/4	1/4	4,850	5,900	2 1/2	2 1/2	1 1/2	1 1/2
40	388	170	558	54	12 3	9 0	13	26	48	36	6 0	180	60	22	3/8	3/8	3/8	5,500	6,700	2 1/2	2 1/2	1 1/2	1 1/2
50	437	195	632	54	14 1	10 6	15	28	48	36	7 6	164	60	24	3/8	3/8	3/8	7,300	8,500	3	3	1 1/4	1 1/4
60	548	247	795	60	14 2	10 6	15	29	54	36	7 6	208	66	25	3/8	3/8	3/8	8,600	11,000	3	3	1 1/4	1 1/4
75	680	313	993	60	16 6	12 6	18	30	54	36	9 6	208	67	27	1/2	1/2	1/2	10,100	12,500	4	4	1 1/2	1 1/2
100	907	419	1,326	66	17 4	13 0	18	34	60	42	9 6	268	73	30	1/2	1/2	1/2	12,100	15,100	4	4	1 1/2	1 1/2

SPECIFICATIONS OF SUBMERGED HEAD UPRIGHT BOILERS

Horse-Power Based on 9 Sq. Ft. of Water Heating Surface	Water Heating Surface	Superheating Surface	Total Heating Surface	Outside Diameter of Boiler	Height of Boiler from Bottom of Base to Top of Cone	Height of Boiler from Bottom of Leg Ring to Top of Cone	Height of Base	Height of Cone	Inside Diameter of Furnace	Height of Furnace	Length of Tubes 2" Diameter	Number of Tubes 2" Diameter	Diameter of Bottom of Base	Diameter of Opening at Top of Cone	Thickness of Shell	Thickness of Furnace	Thickness of Heads	Thickness of Cone Plate	Weight of Bare Boiler	Weight of Boiler Complete	Size of Steam Outlet	Size of Safety Valve	Size of Blow-off Opening	Size of Feed Pipe
	Sq. Ft.	Sq. Ft.	Sq. Ft.	In.	Ft. In.	Ft. In.	In.	In.	In.	In.	Ft. In.		In.	In.	In.	In.	In.	In.	Lbs.	Lbs.	In.	In.	In.	In.
8	74	11	85	30	8 1	7 0	13	24	25	24	3 0	46	37	16	1/4	1/4	1/4	1,400	1,850	1 1/4	1 1/4	1 1/2	1 1/2	
10	98	12	110	34	8 7	7 6	13	24	28	24	3 6	56	41	16	1/4	1/4	1/4	1,670	2,250	1 1/2	1 1/4	1 1/2	1 1/2	
12	121	13	134	36	9 1	8 0	13	24	30	24	4 0	64	43	18	1/4	1/4	1/4	2,025	2,650	1 1/2	1 1/2	1 1/2	1 1/2	
15	144	14	158	40	9 7	8 6	13	24	34	30	4 0	74	47	18	1/4	1/4	1/4	2,500	3,300	1 1/2	1 1/2	1 1/2	1 1/2	
18	160	14	174	40	9 7	8 6	13	24	34	30	4 0	84	47	18	1/4	1/4	1/4	2,600	3,400	2	2	1 1/2	1 1/2	
20	198	19	217	44	10 7	9 6	13	30	38	30	4 6	96	50	20	1/4	1/4	1/4	3,350	4,175	2	2	1	1	
25	243	20	263	48	10 7	9 6	13	30	42	30	4 6	120	54	20	1/4	1/4	1/4	3,800	4,650	2	2	1	1	
30	277	20	290	48	10 7	9 6	13	30	42	30	4 6	136	54	20	1/4	1/4	1/4	4,050	4,900	2 1/2	2	1	1	
35	322	20	342	48	11 7	10 6	13	30	42	30	5 6	140	54	20	1/4	1/4	1/4	4,650	5,500	2 1/2	2	1	1	
40	388	23	411	54	11 7	10 6	13	30	48	36	5 0	180	60	22	3/8	3/8	3/8	5,350	6,350	2 1/2	2 1/2	1	1	
50	437	29	466	54	13 7	12 6	13	36	48	36	6 6	164	60	24	3/8	3/8	3/8	7,100	9,300	3	2 1/2	1 1/4	1	

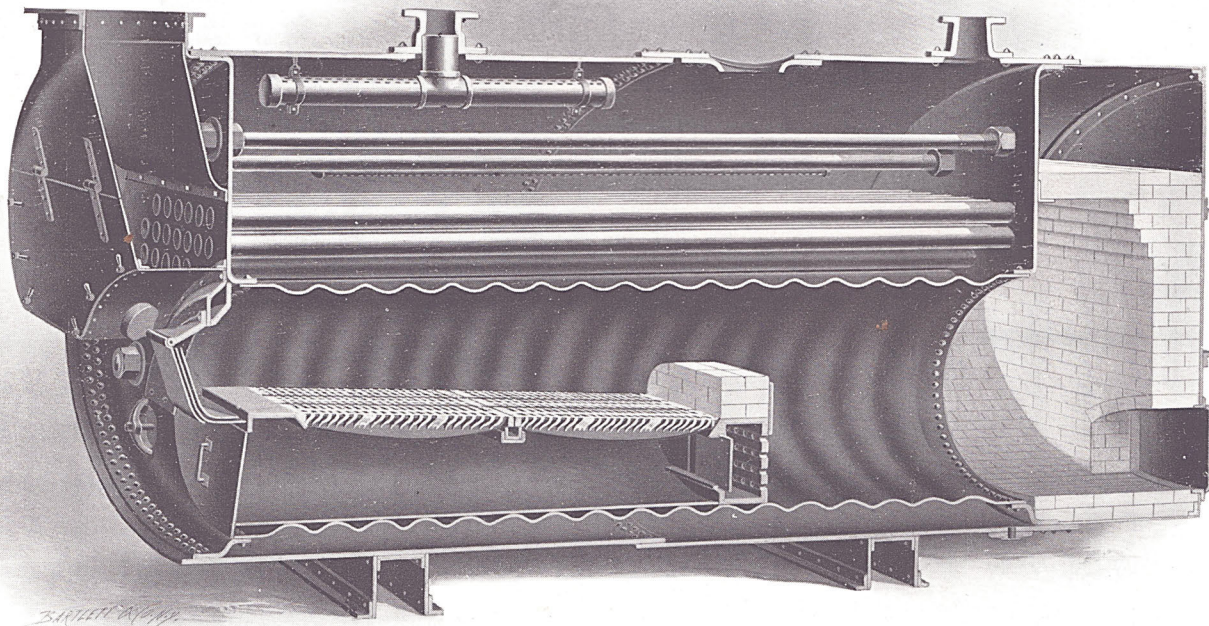


PLATE 48
Illustrating Internally Fired Boiler of Continental Type

Internally Fired Boilers of the Continental Type

Plate 48 illustrates the Bigelow Internally Fired Boiler with a cross-sectional view in perspective.

Horse-power

We build these boilers in units of from 75 to 300 horse-power for any desired working pressure up to 200 pounds. The rating of these boilers has been made upon the basis of an evaporation of 30 pounds of water per hour from a temperature of 100° Fahrenheit into steam at 70 pounds gauge pressure, making an equivalent of 34½ pounds at 212°.

The drawings shown on page 53 illustrate very clearly the general construction of the boiler.

Efficiency

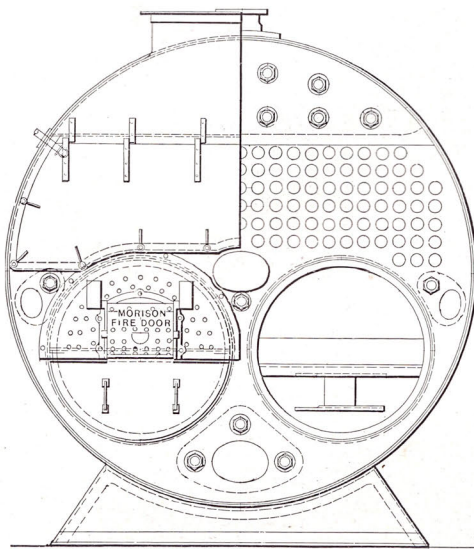
Where space is very limited, this boiler may be used to advantage. In proportion to the amount of floor space and head room required it will develop a great amount of horse-power. Attention is directed to the table of specifications giving the general dimensions and sizes of these boilers.

Construction

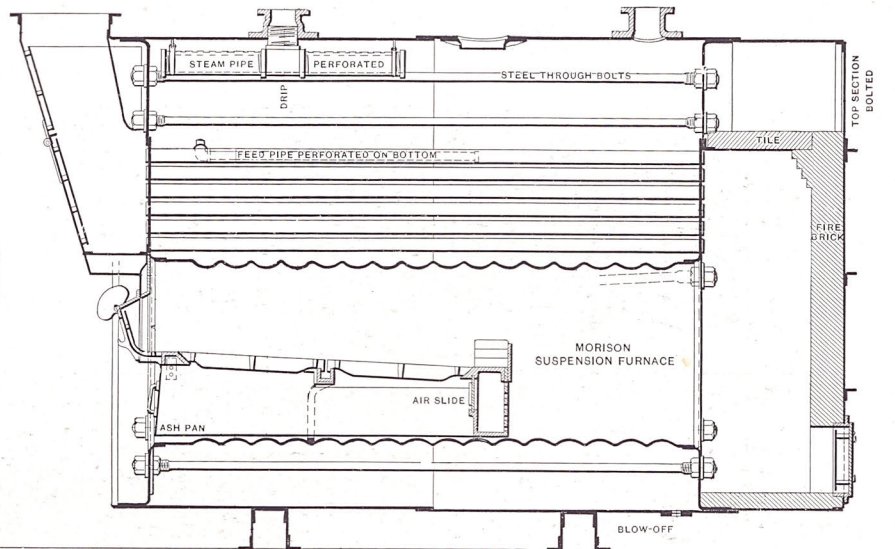
The principle of construction, the material and the workmanship upon this boiler reach the standard of efficiency maintained in all Bigelow Boilers.

Detailed specifications of these boilers will be furnished upon request.

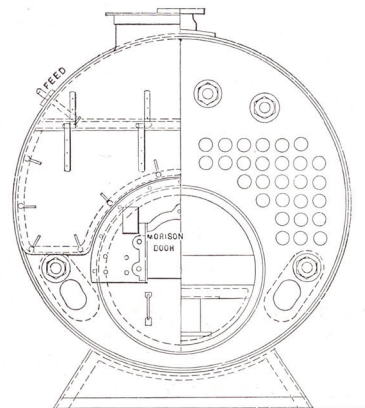
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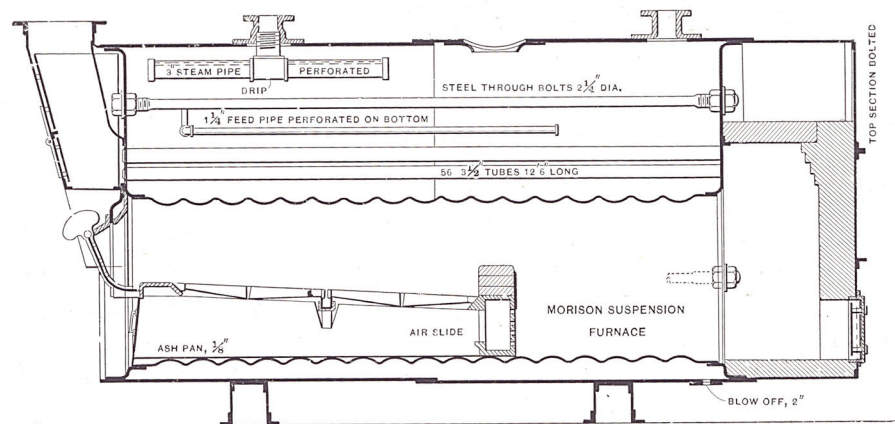
FRONT ELEVATION.
FRONT ELEVATION,
WITH BREECHING REMOVED.



LONGITUDINAL SECTION



FRONT ELEVATION.
FRONT ELEVATION
WITH BREECHING REMOVED



LONGITUDINAL SECTION

SPECIFICATIONS

Rated Horse-power	Grate Surface in Square Feet	Heating Surface in Square Feet	Ratio of Heating Surface to Grate Surface	Diameter of Tubes in Inches	Number of Tubes	Length of Tubes in Feet and Inches	Area Through Tubes in Square Feet	Ratio Area Through Tubes to Grate Surface	Inside Diameter of Boiler Shell in Feet and Inches	Inside Diameter of Corrugated Furnace in Inches	Length of Grate in Feet and Inches	Depth of Combustion Chamber in Feet and Inches
75	15	527	35.2 to 1	3 1/2	42	11 6	2.44	1 to 6.15	6 6	36	5 0	2 0
100	20	733	36.6 to 1	3 1/2	56	12 6	3.25	1 to 6.15	7 0	38	6 4	2 6
125	25	905	36.2 to 1	3 1/2	70	12 6	4.06	1 to 6.15	7 6	45	6 8	2 6
150	30	1,071	35.7 to 1	3 1/2	80	13 0	4.64	1 to 6.46	8 0	50	7 3	2 6
200	40	1,423	35.6 to 1	3 1/2	108	12 6	6.26	1 to 6.39	9 6	38	6 4	2 6
250	50	1,780	35.6 to 1	3 1/2	137	12 6	7.95	1 to 6.40	10 6	45	6 8	2 6
300	60	2,157	35.9 to 1	3 1/2	161	13 0	9.34	1 to 6.42	11 6	50	7 3	2 6

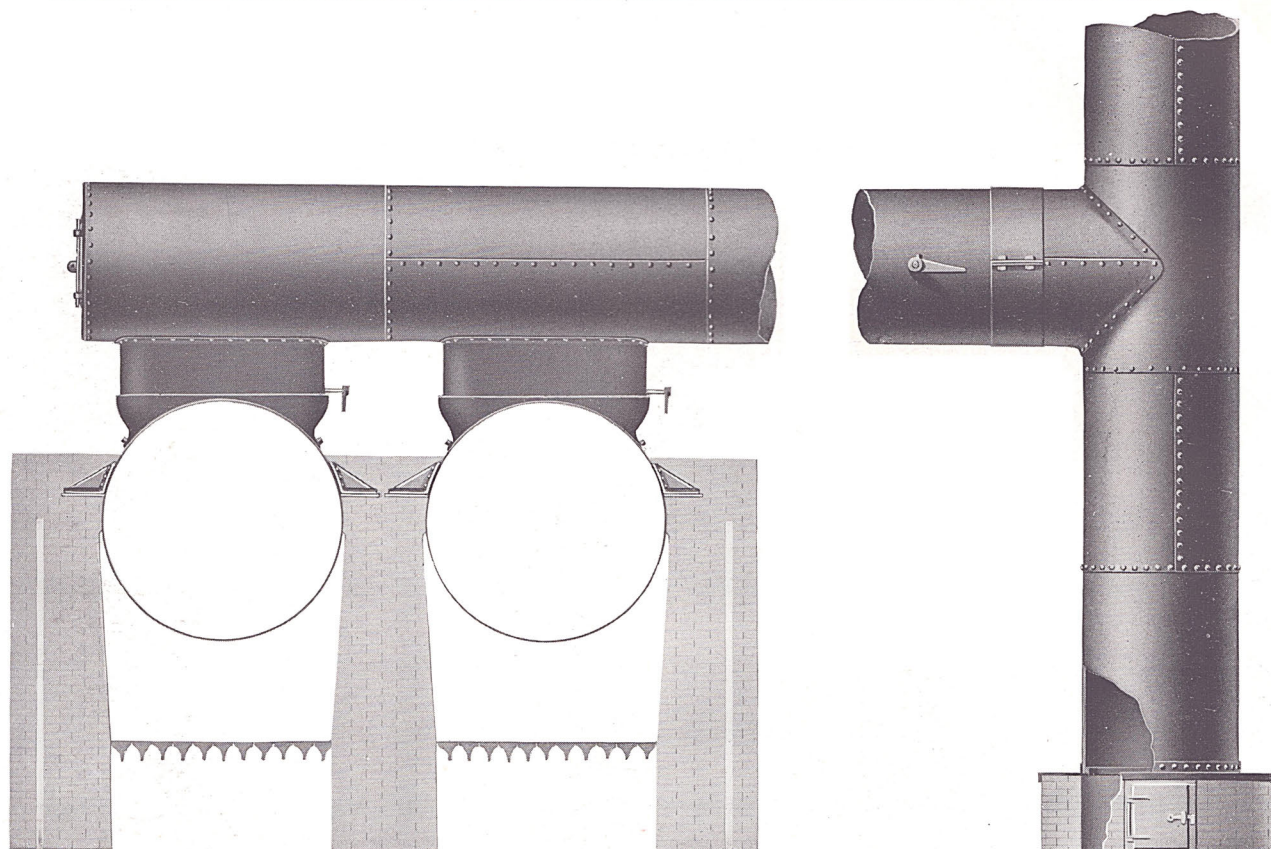


PLATE 49

Illustrating Round Type of Smoke Flue in connection with two Horizontal Return Tubular Boilers

Smoke Flues

Round Flues

The round type of flue (see Plate 49) is generally used for small installations, because if built much larger than four feet in diameter it is apt to lose its shape.

Rectangular Flues

A rectangular flue (see Plate 51) keeps its shape much better than the round. It is easier to assemble and is specially recommended for large installations. With it sufficient area can be obtained by making it of almost any necessary rectangular shape, that is to say, narrow and high or *vice versa*. We make our rectangular flues by flanging over the two edges on the opposite sides—for instance, at the top and bottom of the flue. The two side plates are then riveted to these flanged edges. The actual method of construction may easily be seen by referring to Plate 50. Stability is assured by placing angle iron at proper distance along the flue and by the constructing of the corners referred to above.

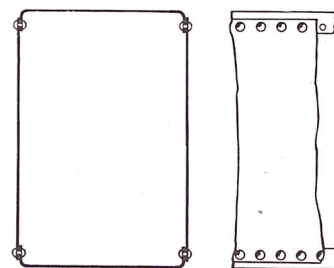


PLATE 50

Section of Rectangular Smoke Flue showing construction, the top and bottom of flue being flanged and the sides riveted to them

Flue Areas Required

The table reproduced on page 55 shows the areas recommended in flues for different size horse-power installations.

When supplying flues with our boilers we furnish what are known as cast-iron risers with a damper in them and a lever for operating (see Plate 20). These risers are bolted to the curtain sheet of the boiler.

Cast-iron risers naturally add materially to the general appearance of the boilers. They also give a stiff support for the damper and allow for slight expansion between the riser and the flue, which is not the case with the ordinary sheet-steel riser or uptake.

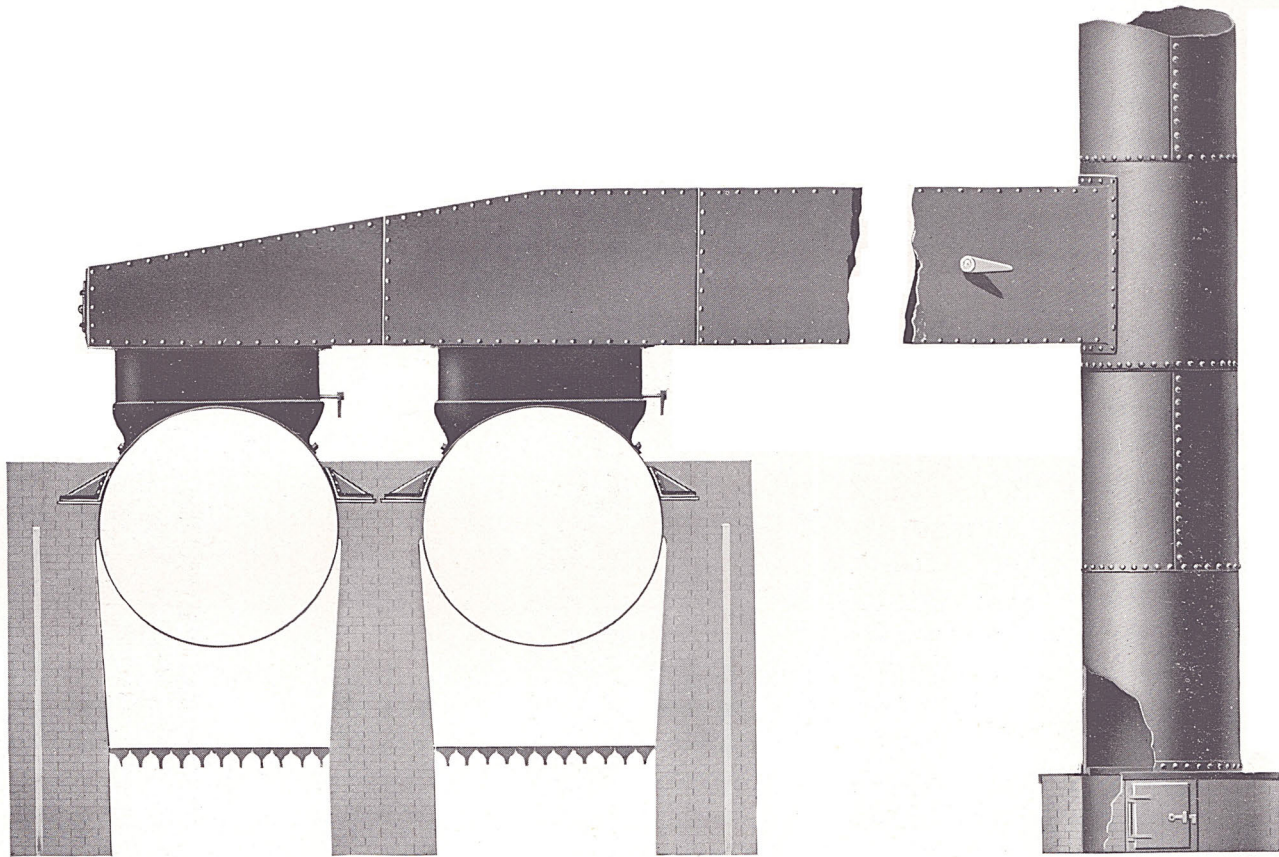


PLATE 51

Illustrating Rectangular Type of Smoke Flue in connection with two Horizontal Return Tubular Boilers

FLUE AREAS REQUIRED, RATED ACCORDING TO BOILER HORSE-POWER

Rated Boiler Horse-Power	Area Flue in Square Feet	Rated Boiler Horse-Power	Area Flue in Square Feet	Rated Boiler Horse-Power	Area Flue in Square Feet	Rated Boiler Horse-Power	Area Flue in Square Feet
50	2.5	600	18.50	1,600	42.50	2,500	63.75
100	4.75	700	20.75	1,700	44.75	2,600	66.25
150	6.25	800	23.25	1,800	47.25	2,700	68.50
200	7.50	900	25.75	1,900	49.50	2,800	70.75
250	9.00	1,000	28.00	2,000	52.00	2,900	73.25
300	10.50	1,100	30.50	2,100	54.25	3,000	75.50
350	12.00	1,200	32.75	2,200	56.50	3,100	78.00
400	13.25	1,300	35.00	2,300	59.00	3,200	80.50
450	14.75	1,400	37.50	2,400	61.50	3,300	82.75
500	15.00	1,500	40.00				

These areas are figured close and should be increased rather than diminished.

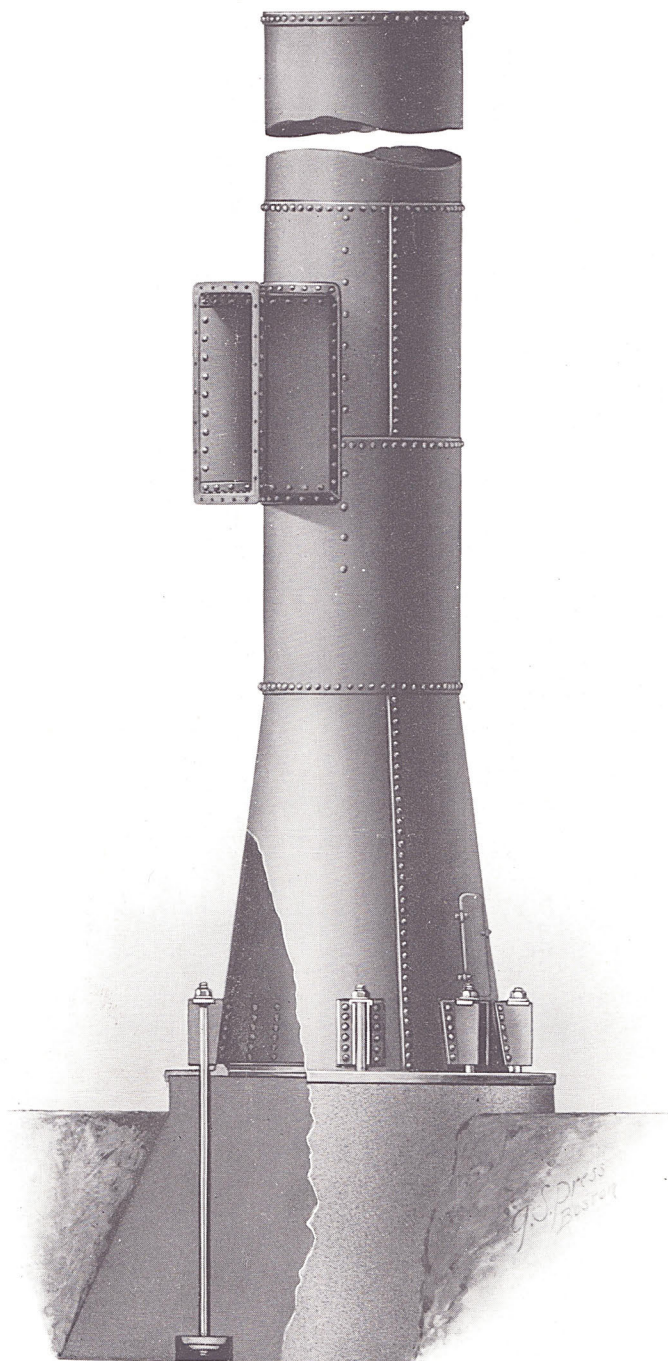


PLATE 52

Illustrating the general construction of Self-sustaining Stack and arrangement of base and anchor bolts, attachment of the lugs on the cone; also re-enforcement of the smoke-flue opening

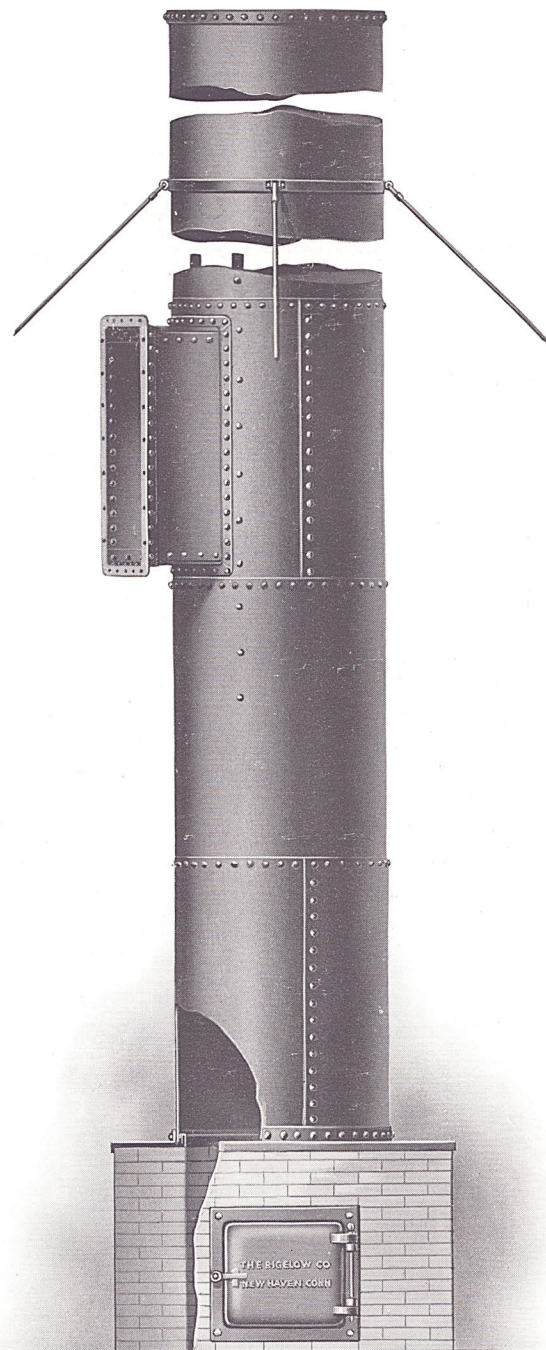


PLATE 53

Illustrating Guyed Stack with arrangement of base we recommend and re-enforcement of flue opening

Stacks

100-FOOT STACKS

Diam. of Stack	Inside Diam. of Stack at Base	Diam. of Top of Foundation	Diam. of Bottom of Foundation	Depth of Foundation	No. of Foundation Bolts	Diam. of Foundation Bolts	Height of Cone	No. of Cubic Feet in Foundation
Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.		In.	Ft. In.	
4 0	6 0	8 0	12 6	6 0	8	2	8 0	519
4 6	8 0	10 0	15 0	7 0	8	2	9 0	895
5 0	8 0	10 0	15 0	7 0	8	2	10 0	895
5 6	9 0	11 0	16 0	7 0	8	2	11 0	1,040
6 0	9 0	11 0	16 6	8 0	8	2	12 0	1,240
6 6	10 0	12 0	17 6	8 0	8	2	13 0	1,415

125-FOOT STACKS

Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.		In.	Ft. In.	
4 0	6 0	8 0	13 0	7 0	8	2½	8 0	640
4 6	8 0	10 0	15 6	8 0	8	2½	9 0	1,070
5 0	8 0	10 0	15 6	8 0	8	2½	10 0	1,070
5 6	9 0	11 0	16 6	8 0	8	2½	11 0	1,240
6 0	9 0	11 0	17 6	9 0	8	2½	12 0	1,507
6 6	10 0	12 0	18 6	9 0	8	2½	13 0	1,719
7 0	12 0	15 0	22 0	9 6	8	2½	14 0	2,650
8 0	12 0	15 0	22 0	9 6	8	2½	16 0	2,650
9 0	14 0	17 0	24 0	9 6	8	2½	18 0	3,210
10 0	15 0	18 0	25 6	10 0	8	2½	20 0	3,820

150-FOOT STACKS

Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.		In.	Ft. In.	
6 0	9 0	11 0	18 6	10 0	10	2½	12 0	1,820
6 6	10 0	12 0	19 6	10 0	10	2½	13 0	2,060
7 0	12 0	15 0	22 6	10 6	10	2½	14 0	3,000
8 0	12 0	15 0	22 6	10 6	10	2½	16 0	3,000
9 0	14 0	17 0	24 6	10 6	10	2½	18 0	3,660
10 0	15 0	18 0	26 0	11 0	10	2½	20 0	4,300

Mr. Kent's table given below on the sizes of stacks recommended for different horse-power boilers may be safely referred to under ordinary conditions, but care should be taken not to follow them too closely where existing conditions are at all unusual.

The annexed table shows the sizes of the most commonly used self-sustaining stacks, giving not only the dimensions but also the foundation and other important data in regard to self-sustaining stacks. The general construction of these stacks will be readily understood after a reference to Plate 52.

With the self-sustaining stacks we furnish all necessary anchor bolts with plates to set in the foundation and steel gusset plates riveted to the cone.

With guyed stacks particular care is taken to furnish a suitable quantity of guy wire, together with all necessary turnbuckles, thimbles and clamps. The construction of guyed stacks is clearly indicated by Plate 53.

With stacks of either type we furnish a cast-iron base, a cleanout door, a nipple on the side of the stack for connecting the flue, a pulley block and wire cable for painting purposes and a band riveted around the top.

Joints on all our stacks are close riveted and calked in the shop. When shipments are made, all sections are carefully assembled and fitted together in the shop. Then they are marked so that when the stacks are being erected all parts will fit accurately.

Self-Sustaining
Stacks

Guyed Stacks

KENT'S TABLE ON SIZES OF CHIMNEYS FOR STEAM BOILER

DIA. INCHES	AREA A Sq. Ft.	HEIGHT OF CHIMNEY														EQUIVALENT SQUARE CHIMNEY. SIDE OF SQUARE $\sqrt{E + 4 \text{ IN.}}$
		50'	60'	70'	80'	90'	100'	110'	125'	150'	175'	200'	225'	250'	300'	
		COMMERCIAL HORSE-POWER OF BOILER														
18	1.77	23	25	27	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16
21	2.41	35	38	41	44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19
24	3.14	49	54	58	62	66	.....	.....	.....	.....	.....	.....	.....	.....	.....	22
27	3.98	65	72	78	83	88	.....	.....	.....	.....	.....	.....	.....	.....	.....	24
30	4.91	84	92	100	107	113	119	.....	.....	.....	.....	.....	.....	.....	.....	27
33	5.94	.....	115	125	133	141	149	156	.....	.....	.....	.....	.....	.....	.....	30
36	7.07	.....	141	152	163	173	182	191	204	.....	.....	.....	.....	.....	.....	32
39	8.30	.....	.....	183	196	208	219	229	268	268	.....	.....	.....	.....	.....	35
42	9.62	.....	.....	216	231	245	258	271	289	316	342	.....	.....	.....	.....	38
48	12.57	.....	.....	.....	311	330	348	365	389	426	460	492	.....	.....	.....	43
54	15.90	.....	.....	.....	.....	427	449	472	503	551	595	636	675	.....	.....	48
60	19.64	.....	.....	.....	.....	536	565	593	632	692	748	800	848	894	.....	54
66	23.76	.....	.....	.....	.....	.....	694	728	776	849	918	981	1,040	1,097	1,201	59
72	28.27	.....	.....	.....	.....	.....	835	876	934	1,023	1,105	1,181	1,253	1,320	1,447	64
78	33.18	.....	.....	.....	.....	.....	.....	1,038	1,107	1,212	1,310	1,400	1,485	1,565	1,715	70
84	38.48	.....	.....	.....	.....	.....	.....	1,214	1,294	1,418	1,531	1,637	1,736	1,830	2,005	75
90	44.18	.....	.....	.....	.....	.....	.....	.....	1,496	1,639	1,770	1,893	2,008	2,116	2,318	80
96	50.27	.....	.....	.....	.....	.....	.....	.....	1,712	1,876	2,027	2,167	2,298	2,423	2,654	86
102	56.75	.....	.....	.....	.....	.....	.....	.....	1,944	2,130	2,300	2,459	2,609	2,750	3,012	91
108	63.62	.....	.....	.....	.....	.....	.....	.....	2,090	2,399	2,592	2,771	2,939	3,098	3,393	96
114	70.88	.....	.....	.....	.....	.....	.....	.....	.....	2,685	2,900	3,100	3,288	3,466	3,797	101
120	78.54	.....	.....	.....	.....	.....	.....	.....	.....	2,986	3,226	3,448	3,657	3,855	4,223	107
132	95.03	.....	.....	.....	.....	.....	.....	.....	.....	3,637	3,929	4,200	4,455	4,696	5,144	117
144	113.10	.....	.....	.....	.....	.....	.....	.....	.....	4,352	4,701	5,026	5,331	5,618	6,155	128

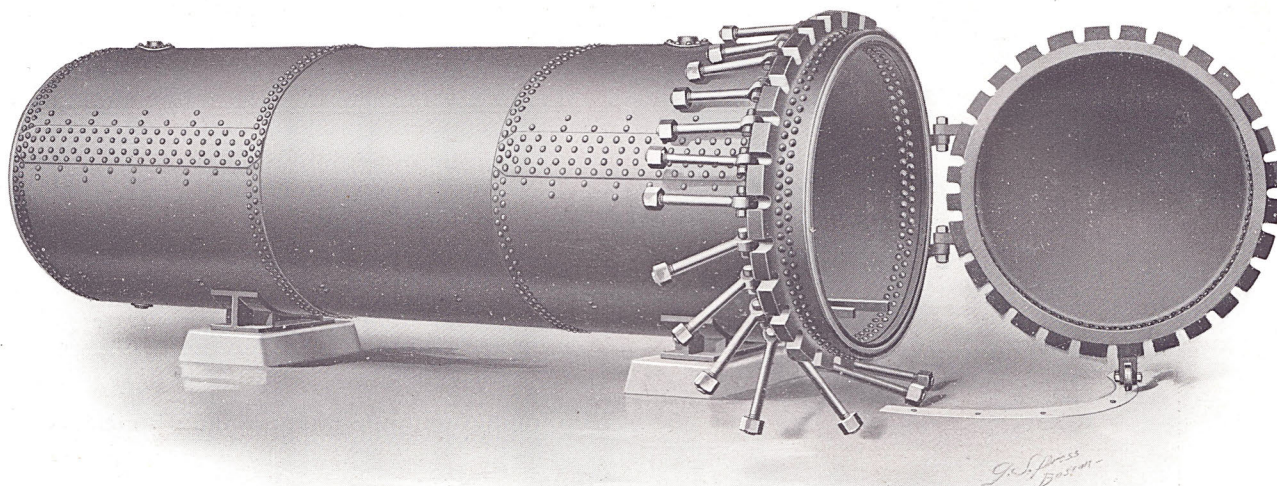


PLATE 54
Illustrating Vulcanizer with door open

Devulcanizers

The Principle

In the construction of devulcanizers and vessels of a similar character requiring that one head be made removable, there are two main points to be considered, the strength and safety of the several parts and the ease with which the removable head may be manipulated. Our devulcanizer design obtains these features in ideal form.

The Construction

The longitudinal seams are of the triple or quadruple riveted butt strapped type. The heads of both the closed and the removable ends of these vessels are of the bumped spherical form. A glance at the cut (Plate 55) will show that we have reversed the usual positions of the flanges on the rings at the open end, and a little thought on the subject will show how advantageous this is, both in the operation of the devulcanizer and in producing maximum strength. The strains produced in the rings of such vessels are dependent on the internal pressure carried and the distance between the center of the cover bolts and the packing ring; this dimension is required to be a minimum to produce maximum strength of ring. Our design for these rings locates the cover bolts directly against the hub of the ring, which places them as near the packing circle as it is possible to put them. Another feature of equal importance is that the bolt ends project directly from a flat surface, and there is also no interference on account of the dishing of the head, so that the nuts on these bolts are perfectly accessible for manipulation with an ordinary open-ended wrench, and the use of a socket wrench or other special appliance is not required.

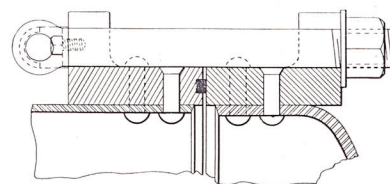


PLATE 55
Illustrating Cross-Section of Ring
used on Vulcanizers

Ring and Cover Bolts

The cover bolts are permanently hinged to the ring on the shell, which greatly adds to the ease in manipulation, and they are of such size that the working strain does not exceed 6,000 pounds per square inch of net section of the bolts. This limit for the working stress is a very important point in producing safety and long life where bolts require constant manipulation.

Track and Carriage

When desired we will furnish carriages and tracks suitably designed to suit circumstances of operation.

We have had exceptional experience in this class of construction, and we have abandoned the use of any material except cast steel for making the flange rings.

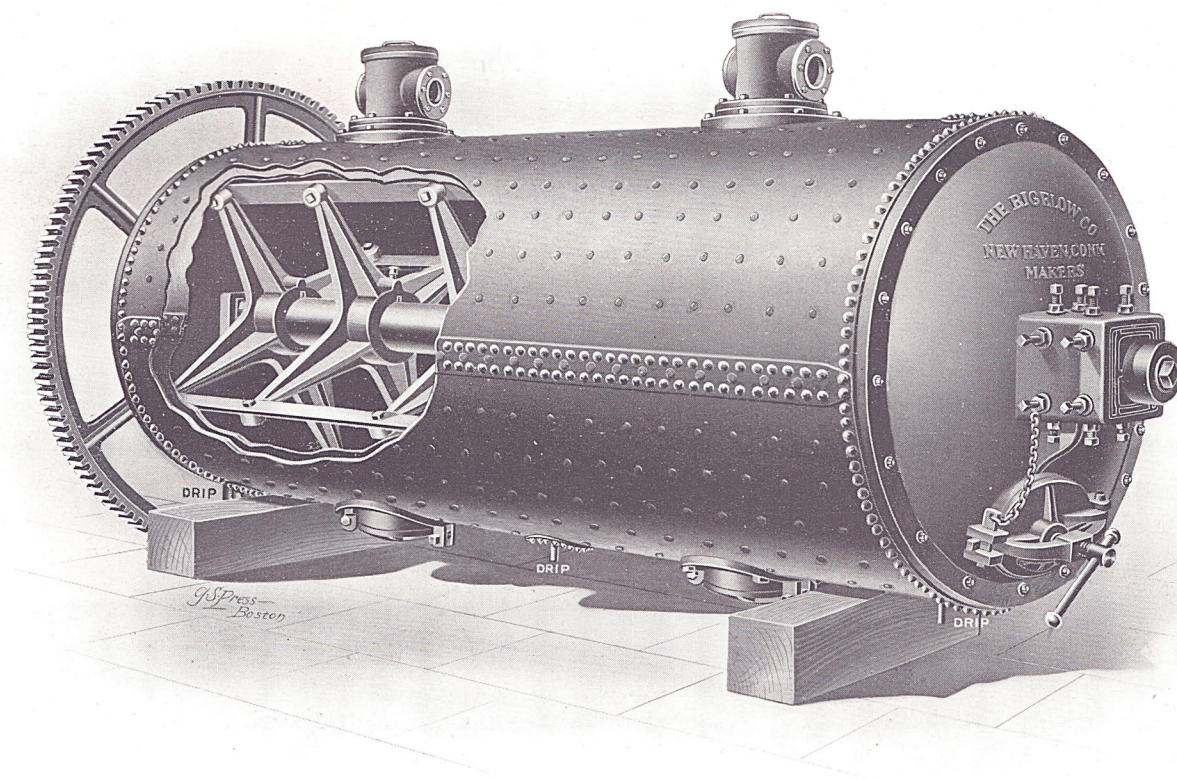


PLATE 56

Illustrating the Hogel Dryer with shell cut away, showing arrangement of reel inside of dryer

The Hogel Dryer

The Hogel Dryer shown in Plate No. 56 is very efficient as to the work performed. It takes a comparatively small amount of power to run this type of dryer as compared with type where shell revolves. It needs but little study to become convinced that it takes less power to turn the paddles than the shell, keeping the shell stationary, than *vice versa*, namely, having the reel stationary and revolving the shell, which is often the case. Also, the life of this dryer is almost double that of any other on the market, owing to the fact that it is reversible; that is to say, when the lower part becomes worn from use it can be turned and the top can be used for the bottom. The bearings are properly babbitted and the workmanship and material, in every detail, of the best.

SPECIFICATIONS

Number of Size	1	2	3
Diameter, inches, inside	48	54	60
Length, feet, inside	8	14	15
Thickness outside shell, inches	$\frac{7}{16}$	$\frac{7}{16}$	$\frac{7}{16}$
Thickness inside shell, inches	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{1}{16}$
Diameter of gear, inches	48	72	72
Diameter of pinion, inches	7	7	7
Number of revolutions of pinion	62	62	62
Number of revolutions of reel	9	6	6
Total weight in pounds	7,000	13,450	20,000

The length of dryers can be changed to suit requirements.

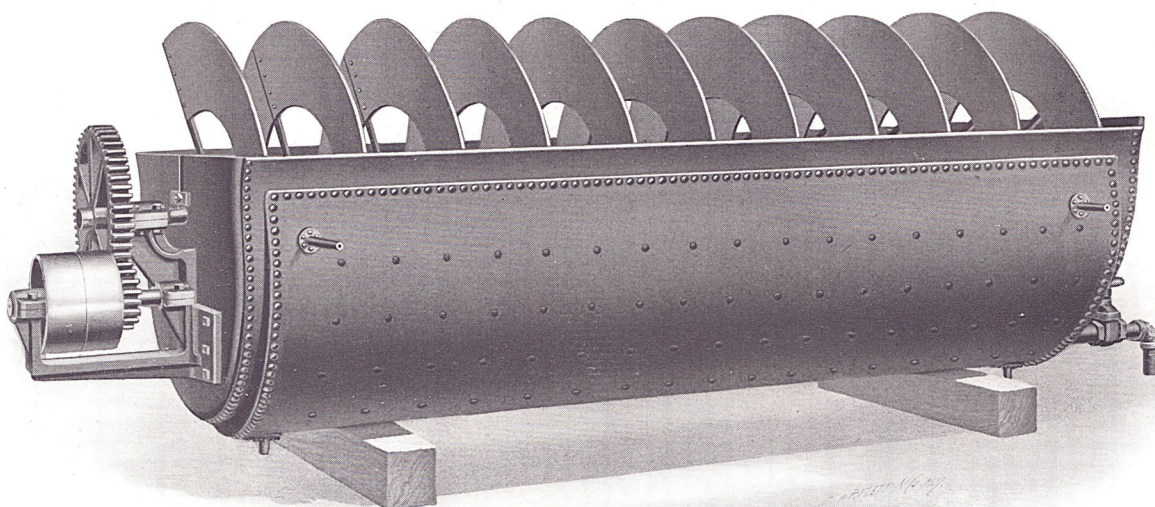


PLATE 57
Illustrating Standard Lard Cooler

Digesters and Lard Coolers

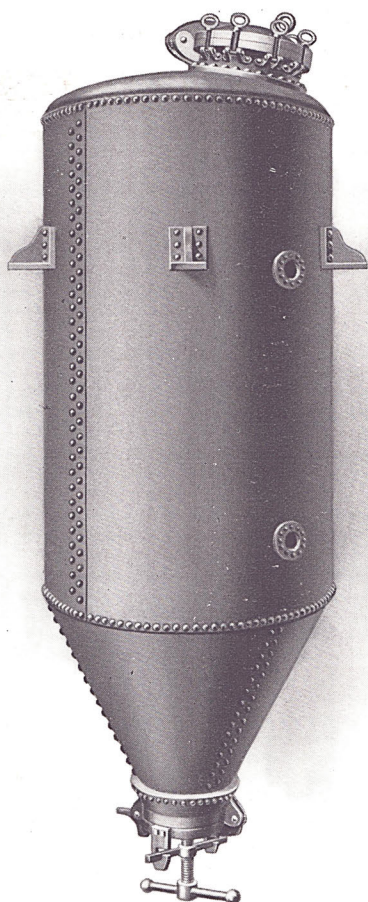


PLATE 58
Illustrating Standard Digester

Plate 57 shows our design of Lard Cooler and 58 shows Digester, both of which are indispensable in Slaughter or Packing Houses. As to the Digester, the top head is dished, and eliminates any internal braces, which are very apt to be eaten away by the chemical action of the material used within this Digester. We make these of nearly any size desired. Those most generally used are 4' and 5' in diameter and 10' to 12' long. Thickness of shell varies from $\frac{3}{8}$ " to $\frac{1}{2}$ ", depending upon pressure desired, and all seams are calked inside and outside. The swinging door at the bottom is made with great care, there being a ground joint, so there is no trouble from leakage.

We build these Digesters in the jacketed form as well, which are used when a large amount of moisture is desired to be gotten rid of from the material. We test these under hydrostatic pressure fifty per cent over the working pressure, making them thoroughly tight in every way.

With our Lard Coolers, such as shown on Plate 57, we furnish gear, pinion, tight and loose pulleys. As to the size of these, they vary such as circumstances call for.

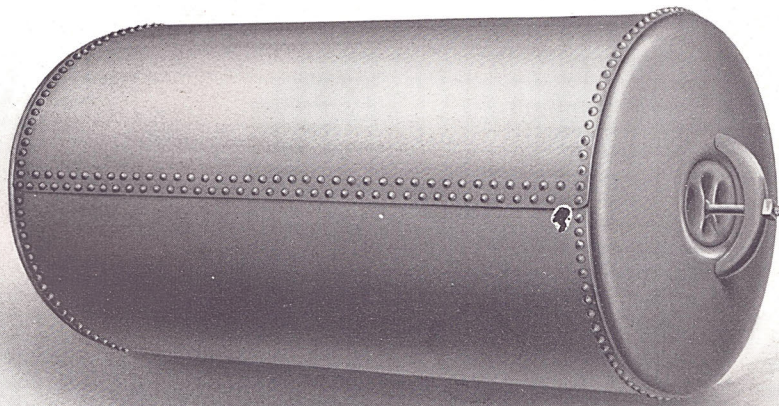


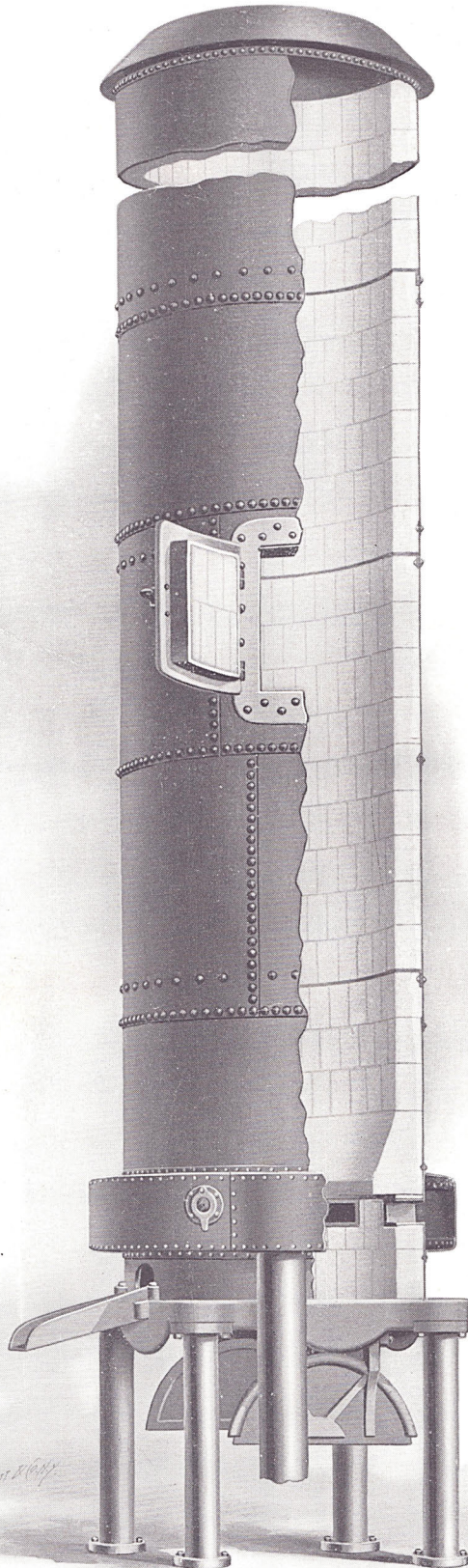
PLATE 59
Illustrating Pressure Tank

Pressure Tanks and Bleaching Kiers

Plate 59 shows the general construction of our pressure tanks and Plate 60 our Bleaching Kiers. We build either of these articles in any size desired and for any pressure. The workmanship and material throughout are of the very best, and we test same under hydrostatic pressure fifty per cent over the working pressure that it is designed for.



PLATE 60
Illustrating Bleaching Kier



Cupolas

In accompanying cut (Plate 61) are shown the general construction and detail of our cupolas. We furnish all materials illustrated with the exception of the fire-brick and wind pipe. The following table gives different sizes and general dimensions of these cupolas.

Our cupolas, properly managed, should melt 9 to 10 pounds of iron to one pound of coal.

THE BIGELOW FOUNDRY CUPOLA

Number of Size	Diameter of Shell in Inches	Height of Shell from Top of Columns in Feet	Thickness of Stock for Bottom Course in Inches	Thickness of Stock from Top of Bottom Course to Top of Charging Door in Inches	Thickness of Stock from Top of Charging Door to Top of Cupola in Inches	Total Weight in Pounds	Capacity per Hour in Tons
1	40	26	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{8}$	4,900	2
2	44	26	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{8}$	5,900	3
3	54	26	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{8}$	6,200	4 $\frac{1}{2}$
4	60	26	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{16}$ and $\frac{1}{8}$	9,400	5 $\frac{1}{2}$
5	66	26	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{16}$ and $\frac{1}{8}$	11,400	6
6	72	26	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{16}$ and $\frac{1}{8}$	13,300	7

PLATE 61

Illustrating general view of Standard Cupola

SUPERHEATED STEAM

Taken by permission from Marks and Davis' Tables and Diagrams, copyright 1909 by Longmans, Green & Co.

		DEGREES OF SUPERHEAT																								Press. Lbs.
Press. Lbs.	Water	Sat. Steam	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°	140°	150°	160°	170°	180°	190°	200°	250°	300°		
100 t	0.02	327.8	337.8	347.8	357.8	367.8	377.8	387.8	397.8	407.8	417.8	427.8	437.8	447.8	457.8	467.8	477.8	487.8	497.8	507.8	517.8	527.8	577.8	627.8		
v	298.3	4.43	4.51	4.58	4.65	4.72	4.79	4.86	4.93	5.00	5.07	5.14	5.21	5.27	5.34	5.41	5.47	5.54	5.61	5.67	5.74	5.80	6.12	6.44		
h	0.4743	1.0620	1.1920	1.197.5	1.203.0	1.208.4	1.213.8	1.219.1	1.224.3	1.229.5	1.234.6	1.239.7	1.244.7	1.249.7	1.254.7	1.259.7	1.264.7	1.269.6	1.274.6	1.279.5	1.284.4	1.289.4	1.313.6	1.337.8		
n			1.6091	1.6160	1.6228	1.6294	1.6358	1.6420	1.6481	1.6541	1.6600	1.6658	1.6714	1.6770	1.6826	1.6880	1.6933	1.6985	1.7037	1.7088	1.7138	1.7188	1.7428	1.7656		
125 t	0.02	344.4	354.4	364.4	374.4	384.4	394.4	404.4	414.4	424.4	434.4	444.4	454.4	464.4	474.4	484.4	494.4	504.4	514.4	524.4	534.4	544.4	594.4	644.4		
v	315.5	3.58	3.64	3.70	3.76	3.82	3.88	3.94	4.00	4.06	4.11	4.17	4.22	4.28	4.33	4.39	4.45	4.50	4.55	4.60	4.65	4.71	4.97	5.23		
h	0.4959	1.0903	1.196.2	1.202.0	1.207.7	1.213.3	1.218.8	1.224.2	1.229.5	1.234.8	1.240.0	1.245.1	1.250.2	1.255.3	1.260.4	1.265.5	1.270.4	1.275.4	1.280.3	1.285.3	1.290.3	1.295.2	1.319.5	1.343.8		
n			1.5913	1.5983	1.6052	1.6119	1.6183	1.6246	1.6307	1.6367	1.6426	1.6484	1.6540	1.6595	1.6650	1.6703	1.6755	1.6807	1.6858	1.6909	1.6959	1.7007	1.7245	1.7470		
150 t	0.02	358.5	368.5	378.5	388.5	398.5	408.5	418.5	428.5	438.5	448.5	458.5	468.5	478.5	488.5	498.5	508.5	518.5	528.5	538.5	548.5	558.5	608.5	658.5		
v	330.2	3.01	3.06	3.11	3.17	3.22	3.27	3.32	3.37	3.42	3.46	3.51	3.56	3.61	3.66	3.70	3.75	3.80	3.84	3.88	3.92	3.97	4.19	4.41		
h	0.5142	1.193.4	1.199.6	1.205.7	1.211.6	1.217.3	1.223.0	1.228.5	1.233.9	1.239.2	1.244.4	1.249.6	1.254.8	1.259.9	1.265.0	1.270.1	1.275.1	1.280.1	1.285.1	1.290.1	1.295.1	1.300.0	1.324.5	1.348.8		
n			1.5768	1.5840	1.5910	1.5978	1.6043	1.6106	1.6168	1.6227	1.6286	1.6343	1.6399	1.6453	1.6507	1.6560	1.6612	1.6663	1.6714	1.6764	1.6813	1.6862	1.7097	1.7320		
175 t	0.02	370.8	380.8	390.8	400.8	410.8	420.8	430.8	440.8	450.8	460.8	470.8	480.8	490.8	500.8	510.8	520.8	530.8	540.8	550.8	560.8	570.8	620.8	670.8		
v	343.2	2.60	2.65	2.69	2.74	2.78	2.83	2.87	2.91	2.96	3.00	3.04	3.08	3.12	3.16	3.20	3.24	3.28	3.32	3.36	3.40	3.44	3.63	3.82		
h	0.5299	1.3567	1.3646	1.3720	1.3792	1.3860	1.3926	1.3989	1.4051	1.4110	1.4168	1.4224	1.4280	1.4334	1.4387	1.4439	1.4491	1.4542	1.4592	1.4642	1.4691	1.4937	1.518.2			
n			1.5646	1.5720	1.5792	1.5860	1.5926	1.5989	1.6051	1.6110	1.6168	1.6224	1.6280	1.6334	1.6387	1.6439	1.6491	1.6542	1.6592	1.6642	1.6691	1.6740	1.6971	1.7193		
200 t	0.02	381.9	391.9	401.9	411.9	421.9	431.9	441.9	451.9	461.9	471.9	481.9	491.9	501.9	511.9	521.9	531.9	541.9	551.9	561.9	571.9	581.9	631.9	681.9		
v	354.9	2.20	2.23	2.27	2.31	2.35	2.40	2.43	2.47	2.51	2.54	2.58	2.62	2.66	2.70	2.74	2.78	2.82	2.86	2.90	2.94	2.97	3.21	3.38		
h	0.5437	1.4556	1.4635	1.4716	1.4795	1.4873	1.4950	1.5026	1.5101	1.5175	1.5248	1.5321	1.5393	1.5464	1.5535	1.5605	1.5675	1.5744	1.5812	1.5880	1.5947	1.6192	1.6437			
n			1.5538	1.5614	1.5687	1.5757	1.5823	1.5886	1.5947	1.6007	1.6064	1.6120	1.6175	1.6229	1.6282	1.6334	1.6385	1.6435	1.6485	1.6534	1.6583	1.6632	1.6862	1.7082		
225 t	0.02	391.9	401.9	411.9	421.9	431.9	441.9	451.9	461.9	471.9	481.9	491.9	501.9	511.9	521.9	531.9	541.9	551.9	561.9	571.9	581.9	591.9	641.9	691.9		
v	365.5	2.05	2.09	2.12	2.15	2.19	2.23	2.26	2.30	2.33	2.37	2.40	2.43	2.47	2.50	2.53	2.57	2.60	2.63	2.66	2.69	2.72	2.98	3.03		
h	0.5562	1.5361	1.5447	1.5525	1.5600	1.5671	1.5738	1.5800	1.5861	1.5920	1.5977	1.6033	1.6088	1.6141	1.6194	1.6245	1.6296	1.6346	1.6396	1.6445	1.6493	1.6542	1.6771	1.6988		
n			1.5447	1.5525	1.5600	1.5671	1.5738	1.5800	1.5861	1.5920	1.5977	1.6033	1.6088	1.6141	1.6194	1.6245	1.6296	1.6346	1.6396	1.6445	1.6493	1.6542	1.6771	1.6988		
250 t	0.02	401.0	411.0	421.0	431.0	441.0	451.0	461.0	471.0	481.0	491.0	501.0	511.0	521.0	531.0	541.0	551.0	561.0	571.0	581.0	591.0	601.0	651.0	701.0		
v	375.2	1.85	1.88	1.91	1.95	1.98	2.02	2.05	2.08	2.11	2.14	2.17	2.21	2.24	2.27	2.30	2.33	2.36	2.38	2.41	2.44	2.47	2.61	2.75		
h	0.572	1.201.5	1.206.9	1.212.3	1.217.6	1.222.9	1.228.1	1.233.3	1.238.5	1.243.6	1.248.7	1.253.8	1.258.9	1.263.9	1.268.9	1.273.9	1.278.9	1.283.9	1.288.9	1.293.9	1.298.9	1.303.9	1.328.4	1.352.9		
n			1.5364	1.5445	1.5521	1.5593	1.5660	1.5723	1.5784	1.5843	1.5900	1.5956	1.6010	1.6062	1.6114	1.6165	1.6216	1.6266	1.6315	1.6364	1.6412	1.6460	1.6688	1.6905		

t = temperature in F. degs.
v = sp. vol. in cu. ft. per lb.
h = total heat in B. t. u.
n = entropy.

T° Fahr. absolute = t° + 459.6°.
J = 777.5 ft. lbs. per B. t. u. [log = 2.89 071].
A = 1/2 = 1.286 × 10⁻³ B. t. u. per ft. lb. [3.10 929].
144 A = 0.1852 [log = 1.26 704].

Internal energy
= total heat - 144 Apv.
Values for saturated steam
are given in table on page 64.

CONVERSION FROM METRIC UNITS
1 kg. per sq. cm. = 14.22 lbs. per sq. in. [log = 1.15 300]. 1 cu. meter = 35.31 cu. ft. [log = 1.54 795]
To change degs. C. to degs. F., multiply by 9/5, and add 32. To change mean kg.
calories per kg. to mean B. t. u. per lb., multiply by 3/4. Entropy same in both systems.

THE BIGELOW COMPANY, NEW HAVEN, CONNECTICUT

SATURATED STEAM PRESSURE TABLE

Taken by permission from Marks and Davis' Tables and Diagrams, copyright 1909 by Longmans, Green & Co.

Press. lbs. p	Temp. Deg. F. t	Press. Atmos.* —	Sp. Vol. cu. ft. per lb. v or s	Density lbs. per cu. ft. 1/v	Heat of the liquid h or q	Latent heat of evap. L or r	Total heat of steam H	Internal Energy B. t. u.		Entropy			Press. lbs. p
								Evap. I or ρ	Steam E	Water n or θ	Evap. L/T or r/T	Steam N or φ	
1	101.83	0.068	333.0	0.00300	69.8	1034.6	1104.4	972.9	1042.7	0.1327	1.8427	1.9754	1
2	126.15	0.136	173.5	0.00576	94.0	1021.0	1115.0	956.7	1050.7	0.1749	1.7431	1.9180	2
3	141.52	0.204	118.5	0.00845	109.4	1012.3	1121.6	946.4	1055.8	0.2008	1.6840	1.8848	3
4	153.01	0.272	90.5	0.01107	120.9	1005.7	1126.5	938.6	1059.5	0.2198	1.6416	1.8614	4
5	162.28	0.340	73.33	0.01364	130.1	1000.3	1130.5	932.4	1062.5	0.2348	1.6804	1.8432	5
6	170.06	0.408	61.89	0.01616	137.9	995.8	1133.7	927.0	1064.9	0.2471	1.5814	1.8285	6
7	176.85	0.476	53.56	0.01867	144.7	991.8	1136.5	922.4	1067.1	0.2579	1.5582	1.8161	7
8	182.86	0.544	47.27	0.02115	150.8	988.2	1139.0	918.2	1069.0	0.2673	1.5380	1.8053	8
9	188.27	0.612	42.36	0.02361	156.2	985.0	1141.1	914.4	1070.5	0.2756	1.5202	1.7958	9
10	193.22	0.680	38.38	0.02606	161.1	982.0	1143.1	910.9	1072.0	0.2832	1.5042	1.7874	10
15	213.0	1.021	26.27	0.03806	181.0	969.7	1150.7	896.8	1077.8	0.3133	1.4416	1.7549	15
20	228.0	1.361	20.08	0.04980	196.1	960.0	1156.2	885.8	1081.9	0.3355	1.3965	1.7320	20
25	240.1	1.701	16.30	0.0614	208.4	952.0	1160.4	876.8	1085.1	0.3532	1.3604	1.7136	25
30	250.3	2.041	13.74	0.0728	218.8	945.1	1163.9	869.0	1087.7	0.3680	1.3311	1.6991	30
35	259.3	2.382	11.89	0.0841	227.9	938.9	1166.8	862.1	1089.9	0.3808	1.3060	1.6868	35
40	267.3	2.722	10.49	0.0953	236.1	933.3	1169.4	855.9	1091.8	0.3920	1.2841	1.6761	40
45	274.5	3.062	9.39	0.1065	243.4	928.2	1171.6	850.3	1093.5	0.4021	1.2644	1.6665	45
50	281.0	3.402	8.51	0.1175	250.1	923.5	1173.6	845.0	1095.0	0.4113	1.2468	1.6581	50
55	287.1	3.742	7.78	0.1285	256.3	919.0	1175.4	840.2	1096.3	0.4196	1.2309	1.6505	55
60	292.7	4.083	7.17	0.1394	262.1	914.9	1177.0	835.6	1097.6	0.4272	1.2160	1.6432	60
65	298.0	4.423	6.65	0.1503	267.5	911.0	1178.5	831.4	1098.7	0.4344	1.2024	1.6368	65
70	302.9	4.763	6.20	0.1612	272.6	907.2	1179.8	827.3	1099.7	0.4411	1.1896	1.6307	70
75	307.6	5.103	5.81	0.1721	277.4	903.7	1181.1	823.5	1100.6	0.4474	1.1778	1.6252	75
80	312.0	5.444	5.47	0.1829	282.0	900.3	1182.3	819.8	1101.6	0.4535	1.1665	1.6200	80
85	316.3	5.784	5.16	0.1937	286.3	897.1	1183.4	816.3	1102.4	0.4590	1.1561	1.6151	85
90	320.3	6.124	4.89	0.2044	290.5	893.9	1184.4	813.0	1103.2	0.4644	1.1461	1.6105	90
95	324.1	6.464	4.65	0.2151	294.5	890.9	1185.4	809.7	1103.9	0.4694	1.1367	1.6061	95
100	327.8	6.80	4.429	0.2258	298.3	888.0	1186.3	806.6	1104.6	0.4743	1.1277	1.6020	100
105	331.4	7.14	4.230	0.2365	302.0	885.2	1187.2	803.6	1105.3	0.4789	1.1191	1.5980	105
110	334.8	7.49	4.047	0.2472	305.5	882.5	1188.0	800.7	1105.9	0.4834	1.1108	1.5942	110
115	338.1	7.83	3.880	0.2577	309.0	879.8	1188.8	797.9	1106.5	0.4877	1.1030	1.5907	115
120	341.3	8.17	3.726	0.2683	312.3	877.2	1189.6	795.2	1107.1	0.4919	1.0954	1.5873	120
125	344.4	8.50	3.583	0.2791	315.5	874.7	1190.3	792.6	1107.7	0.4959	1.0880	1.5839	125
130	347.4	8.85	3.452	0.2897	318.6	872.3	1191.0	790.0	1108.2	0.4998	1.0809	1.5807	130
135	350.3	9.19	3.331	0.3002	321.7	869.9	1191.6	787.5	1108.7	0.5035	1.0742	1.5777	135
140	353.1	9.53	3.219	0.3107	324.6	867.6	1192.2	785.0	1109.2	0.5072	1.0675	1.5747	140
145	355.8	9.87	3.112	0.3213	327.4	865.4	1192.8	782.7	1109.6	0.5107	1.0612	1.5719	145
150	358.5	10.21	3.012	0.3320	330.2	863.2	1193.4	780.4	1110.1	0.5142	1.0550	1.5692	150
155	361.0	10.55	2.920	0.3425	332.9	861.0	1194.0	778.1	1110.5	0.5175	1.0489	1.5664	155
160	363.6	10.89	2.834	0.3529	335.6	858.8	1194.5	775.8	1110.9	0.5208	1.0431	1.5639	160
165	366.0	11.23	2.753	0.3633	338.2	856.8	1195.0	773.6	1111.3	0.5239	1.0376	1.5615	165
170	368.5	11.57	2.675	0.3738	340.7	854.7	1195.4	771.5	1111.7	0.5269	1.0321	1.5590	170
175	370.8	11.91	2.602	0.3843	343.2	852.7	1195.9	769.4	1112.0	0.5299	1.0268	1.5567	175
180	373.1	12.25	2.533	0.3948	345.6	850.8	1196.4	767.4	1112.4	0.5328	1.0215	1.5543	180
185	375.4	12.59	2.468	0.4052	348.0	848.8	1196.8	765.4	1112.8	0.5356	1.0164	1.5520	185
190	377.6	12.93	2.406	0.4157	350.4	846.9	1197.3	763.4	1113.1	0.5384	1.0114	1.5498	190
195	379.8	13.27	2.346	0.4262	352.7	845.0	1197.7	761.4	1113.4	0.5410	1.0066	1.5476	195
200	381.9	13.61	2.290	0.437	354.9	843.2	1198.1	759.5	1113.7	0.5437	1.0019	1.5456	200
205	384.0	13.95	2.237	0.447	357.1	841.4	1198.5	757.6	1114.0	0.5463	0.9973	1.5436	205
210	386.0	14.29	2.187	0.457	359.2	839.6	1198.8	755.8	1114.4	0.5488	0.9928	1.5416	210
215	388.0	14.63	2.138	0.468	361.4	837.9	1199.2	754.0	1114.6	0.5513	0.9885	1.5398	215
220	389.9	14.97	2.091	0.478	363.4	836.2	1199.6	752.3	1114.9	0.5538	0.9841	1.5379	220
225	391.9	15.31	2.046	0.489	365.5	834.4	1199.9	750.5	1115.2	0.5562	0.9799	1.5361	225
230	393.8	15.65	2.004	0.499	367.5	832.8	1200.2	748.8	1115.4	0.5586	0.9758	1.5344	230
235	395.6	15.99	1.964	0.509	369.4	831.1	1200.6	747.0	1115.7	0.5610	0.9717	1.5327	235
240	397.4	16.33	1.924	0.520	371.4	829.5	1200.9	745.4	1115.9	0.5633	0.9676	1.5309	240
245	399.3	16.67	1.887	0.530	373.3	827.9	1201.2	743.7	1116.2	0.5655	0.9638	1.5293	245
250	401.1	17.01	1.850	0.541	375.2	826.3	1201.5	742.0	1116.4	0.5676	0.9600	1.5276	250

* 1 atmo (standard atmosphere) = 760 mms. of Hg. by def. = 29.921 ins. of Hg. = 14.696 lbs. per sq. in.
 For water, at 15 lbs., sp. vol., v' or σ = 0.0167 cu. ft. per lb.; 1/v' = 59.8 lbs. per cu. ft.; 144 Apv' = 0.05 B. t. u.
 For water, at 40 lbs., sp. vol., v' or σ = 0.0171 cu. ft. per lb.; 1/v' = 58.3 lbs. per cu. ft.; 144 Apv' = 0.13 B. t. u.
 T° = t° + 459.6; J = 777.5 ft. lbs. per B. t. u. [log = 2.89 071]; A = 1/J = 1.286 × 10⁻³; 144A = 0.1852 [log = 1.26 764].
 For water, at 65 lbs., sp. vol., v' or σ = 0.0174 cu. ft. per lb.; 1/v' = 57.4 lbs. per cu. ft.; 144 Apv' = 0.21 B. t. u.
 For water, at 90 lbs., sp. vol., v' or σ = 0.0176 cu. ft. per lb.; 1/v' = 56.8 lbs. per cu. ft.; 144 Apv' = 0.30 B. t. u.
 For water, at 115 lbs., sp. vol., v' or σ = 0.0178 cu. ft. per lb.; 1/v' = 56.0 lbs. per cu. ft.; 144 Apv' = 0.38 B. t. u.
 For water, at 140 lbs., sp. vol., v' or σ = 0.0180 cu. ft. per lb.; 1/v' = 55.4 lbs. per cu. ft.; 144 Apv' = 0.47 B. t. u.
 For water, at 165 lbs., sp. vol., v' or σ = 0.0182 cu. ft. per lb.; 1/v' = 54.9 lbs. per cu. ft.; 144 Apv' = 0.56 B. t. u.
 For water, at 190 lbs., sp. vol., v' or σ = 0.0184 cu. ft. per lb.; 1/v' = 54.5 lbs. per cu. ft.; 144 Apv' = 0.65 B. t. u.
 For water, at 215 lbs., sp. vol., v' or σ = 0.0185 cu. ft. per lb.; 1/v' = 54.0 lbs. per cu. ft.; 144 Apv' = 0.74 B. t. u.
 For water, at 240 lbs., sp. vol., v' or σ = 0.0186 cu. ft. per lb.; 1/v' = 53.6 lbs. per cu. ft.; 144 Apv' = 0.83 B. t. u.

THE BIGELOW COMPANY, NEW HAVEN, CONNECTICUT

CYLINDRICAL VESSELS, TANKS, CISTERNS, ETC.

Diameter in Feet and Inches, Area in Square Feet, and U.S. Gallons Capacity for One Foot in Depth

1 gallon = 231 cubic inches = 0.1337 cubic foot

Diam.	Area	Gals.	Diam.	Area	Gals.	Diam.	Area	Gals.	Diam.	Area	Gals.	Diam.	Area	Gals.
Ft. In.	Sq. Ft.	One foot depth	Ft. In.	Sq. Ft.	One foot depth	Ft. In.	Sq. Ft.	One foot depth	Ft. In.	Sq. Ft.	One foot depth	Ft. In.	Sq. Ft.	One foot depth
1	.785	5.87	3 10	11.541	86.33	8	50.27	376.01	16 6	213.82	1599.5	24 9	481.11	3598.9
1 1	.922	6.89	3 11	12.048	90.13	8 3	53.46	399.88	16 9	220.35	1648.4	25	490.87	3672.0
1 2	1.069	8.00	4	12.566	94.00	8 6	56.75	424.48	17	226.98	1697.9	25 3	500.74	3745.8
1 3	1.227	9.18	4 1	13.095	97.96	8 9	60.13	449.82	17 3	233.71	1748.2	25 6	510.71	3820.3
1 4	1.396	10.44	4 2	13.635	102.00	9	63.62	475.89	17 6	240.53	1799.3	25 9	520.77	3895.6
1 5	1.576	11.79	4 3	14.186	106.12	9 3	67.20	502.70	17 9	247.45	1851.1	26	530.93	3971.6
1 6	1.767	13.22	4 4	14.748	110.32	9 6	70.88	530.24	18	254.47	1903.6	26 3	541.19	4048.4
1 7	1.969	14.73	4 5	15.321	114.61	9 9	74.66	558.51	18 3	261.59	1956.8	26 6	551.55	4125.9
1 8	2.182	16.32	4 6	15.90	118.97	10	78.54	587.52	18 6	268.80	2010.8	26 9	562.00	4204.1
1 9	2.405	17.99	4 7	16.50	123.42	10 3	82.52	617.26	18 9	276.12	2065.5	27	572.56	4283.0
1 10	2.640	19.75	4 8	17.10	127.95	10 6	86.59	647.74	19	283.53	2120.9	27 3	583.21	4362.7
1 11	2.885	21.58	4 9	17.72	132.56	10 9	90.76	678.95	19 3	291.04	2177.1	27 6	593.96	4443.1
2	3.142	23.50	4 10	18.35	137.25	11	95.03	710.90	19 6	298.65	2234.0	27 9	604.81	4524.3
2 1	3.409	25.50	4 11	18.99	142.02	11 3	99.40	743.58	19 9	306.35	2291.7	28	615.75	4606.2
2 2	3.687	27.58	5	19.63	146.88	11 6	103.87	776.99	20	314.16	2350.1	28 3	626.80	4688.8
2 3	3.976	29.74	5 1	20.29	151.82	11 9	108.43	811.14	20 3	322.06	2409.2	28 6	637.94	4772.1
2 4	4.276	31.99	5 2	20.97	156.83	12	113.10	846.03	20 6	330.06	2469.1	28 9	649.18	4856.2
2 5	4.587	34.31	5 3	21.65	161.93	12 3	117.86	881.65	20 9	338.16	2529.6	29	660.52	4941.0
2 6	4.909	36.72	5 4	22.34	167.12	12 6	122.72	918.00	21	346.36	2591.0	29 3	671.96	5026.6
2 7	5.241	39.21	5 5	23.04	172.38	12 9	127.68	955.09	21 3	354.66	2653.0	29 6	683.49	5112.9
2 8	5.585	41.78	5 6	23.76	177.72	13	132.73	992.91	21 6	363.05	2715.8	29 9	695.13	5199.9
2 9	5.940	44.43	5 7	24.48	183.15	13 3	137.89	1031.5	21 9	371.54	2779.3	30	706.86	5287.7
2 10	6.305	47.16	5 8	25.22	188.66	13 6	143.14	1070.8	22	380.13	2843.6	30 3	718.69	5376.2
2 11	6.681	49.98	5 9	25.97	194.25	13 9	148.49	1110.8	22 3	388.82	2908.6	30 6	730.62	5465.4
3	7.069	52.88	5 10	26.73	199.92	14	153.94	1151.5	22 6	397.61	2974.3	30 9	742.64	5555.4
3 1	7.467	55.86	5 11	27.49	205.67	14 3	159.48	1193.0	22 9	406.49	3040.8	31	754.77	5646.1
3 2	7.876	58.92	6	28.27	211.51	14 6	165.13	1235.3	23	415.48	3108.0	31 3	766.99	5737.5
3 3	8.296	62.06	6 3	30.68	229.50	14 9	170.87	1278.2	23 3	424.56	3175.9	31 6	779.31	5829.7
3 4	8.727	65.28	6 6	33.18	248.23	15	176.71	1321.9	23 6	433.74	3244.6	31 9	791.73	5922.6
3 5	9.168	68.58	6 9	35.78	267.69	15 3	182.65	1366.4	23 9	443.01	3314.0	32	804.25	6016.2
3 6	9.621	71.97	7	38.48	287.88	15 6	188.69	1411.5	24	452.39	3384.1	32 3	816.86	6110.6
3 7	10.085	75.44	7 3	41.28	308.81	15 9	194.83	1457.4	24 3	461.86	3455.0	32 6	829.58	6205.7
3 8	10.559	78.99	7 6	44.18	330.48	16	201.06	1504.1	24 6	471.44	3526.6	32 9	842.39	6301.5
3 9	11.045	82.62	7 9	47.17	352.88	16 3	207.39	1551.4						

NUMBER OF U.S. GALLONS IN RECTANGULAR TANKS

For One Foot in Depth

Width in feet	LENGTH OF TANK IN FEET																				
	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
2	29.92	37.40	44.88	52.36	59.84	67.32	74.81	82.29	89.77	97.25	104.73	112.21	119.69	127.17	134.65	142.13	149.61	157.09	164.57	172.05	179.53
2.5		46.75	56.10	65.45	74.80	84.16	93.51	102.86	112.21	121.56	130.91	140.26	149.61	158.96	168.31	177.66	187.01	196.36	205.71	215.06	224.41
3			67.32	78.54	89.77	100.99	112.21	123.43	134.65	145.87	157.09	168.31	179.53	190.75	202.97	213.19	224.41	235.63	246.86	258.07	269.30
3.5				91.64	104.73	117.82	130.91	144.00	157.09	170.18	183.27	196.36	209.45	222.54	235.63	248.73	261.82	274.90	288.00	301.09	314.18
4					119.69	134.65	149.61	164.57	179.53	194.49	209.45	224.41	239.37	254.34	269.30	284.26	299.22	314.18	329.14	344.10	359.06
4.5						151.48	168.31	185.14	201.97	218.80	235.63	252.47	269.30	286.13	302.96	319.79	336.62	353.45	370.28	387.11	403.94
5							187.01	205.71	224.41	243.11	261.82	280.52	299.22	317.92	336.62	355.32	374.03	392.72	411.43	430.13	448.83
5.5								226.28	246.86	267.43	288.00	308.57	329.14	349.71	370.28	390.85	411.43	432.00	452.57	473.14	493.71
6									269.30	291.74	314.18	336.62	359.06	381.50	403.94	426.39	448.83	471.27	493.71	516.15	538.59
6.5										316.05	340.36	364.67	388.98	413.30	437.60	461.92	486.23	510.54	534.85	559.16	583.47
7											366.54	392.72	418.91	445.09	471.27	497.45	523.64	549.81	575.99	602.18	628.36
7.5												420.78	448.83	476.88	504.93	532.98	561.04	589.08	617.14	645.19	673.24
8													478.75	508.67	538.59	568.51	598.44	628.36	658.28	688.20	718.12
8.5														540.46	572.25	604.05	635.84	667.63	699.42	731.21	763.00
9															605.92	639.58	673.25	706.90	740.56	774.23	807.89
9.5																675.11	710.65	746.17	781.71	817.24	852.77
10																	748.05	785.45	822.86	860.26	897.66
10.5																		824.73	864.00	903.26	942.56
11																			905.14	946.27	987.43
11.5																				989.29	1032.3
12																					1077.2

EXAMPLE.—To find number of gallons in a rectangular tank that is 7.5 ft. by 10 ft., the water being 4 ft. deep: Look in extreme left-hand column for 7.5 and opposite to this in column headed "10" read 561.04, which being multiplied by 4, the depth of water in the tank, gives 2,244.2, the number of gallons required.

THE BIGELOW COMPANY, NEW HAVEN, CONNECTICUT

STANDARD BOILER TUBES

DIAMETER		THICKNESS		CIRCUMFERENCE		TRANSVERSE AREAS			LENGTH OF TUBE PER SQ. FT.		Nom. Wgt. per ft., lbs.
O. D.	I. D.	In.	Nearest B. W. G.	External	Internal	External	Internal	Metal	Ex. Surf.	In. Surf.	
1	.810	.095	13	3.142	2.545	.7854	.5153	.2701	3.819	4.715	.90
1¼	1.060	.095	13	3.927	3.330	1.2272	.8825	.3447	3.056	3.603	1.15
1½	1.310	.095	13	4.712	4.115	1.7671	1.3478	.4193	2.547	2.916	1.40
1¾	1.560	.095	13	5.498	4.901	2.4053	1.9113	.4940	2.183	2.448	1.66
2	1.810	.095	13	6.283	5.686	3.1416	2.5730	.5686	1.909	2.110	1.91
2¼	2.060	.095	13	7.069	6.472	3.9761	3.3329	.6432	1.698	1.854	2.16
2½	2.282	.109	12	7.854	7.169	4.9087	4.0899	.8188	1.528	1.674	2.75
2¾	2.532	.109	12	8.639	7.954	5.9396	5.0349	.9047	1.389	1.508	3.04
3	2.782	.109	12	9.425	8.740	7.0686	6.0787	.9899	1.273	1.373	3.33
3¼	3.010	.120	11	10.210	9.456	8.2958	7.1157	1.1801	1.175	1.269	3.96
3½	3.260	.120	11	10.996	10.242	9.6211	8.3469	1.274	1.091	1.171	4.28
3¾	3.510	.120	11	11.781	11.027	11.045	9.6762	1.369	1.018	1.088	4.6
4	3.732	.134	10	12.566	11.724	12.566	10.939	1.627	.955	1.024	5.47
4½	4.232	.134	10	14.137	13.295	15.904	14.066	1.838	.849	.902	6.17
5	4.704	.148	9	15.708	14.778	19.635	17.379	2.256	.764	.812	7.58
6	5.670	.165	8	18.850	17.813	28.274	25.249	3.025	.637	.673	10.16
7	6.670	.165	8	21.991	20.954	38.485	34.941	3.544	.546	.573	11.9

TABLE OF EQUATION OF PIPES—Standard Steam and Gas Pipes

Dia.	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Dia.
½		2.27	4.88	15.8	31.7	52.9	96.9	205	377	620	918	1,292	1,767	2,488	3,014	3,786	4,904	5,927	7,321	8,535	9,717	½
¾	2.60		2.05	6.97	14.0	23.3	42.5	90.4	166	273	405	569	779	1,096	1,328	1,668	2,161	2,615	3,226	3,761	4,282	¾
1	7.55	2.90		3.45	6.82	11.4	20.9	44.1	81.1	133	198	278	380	536	649	815	1,070	1,263	1,576	1,837	2,092	1
1½	24.2	9.30	3.20		1.26	3.34	6.13	13.0	23.8	39.2	58.1	81.7	112	157	190	239	310	375	463	539	614	1½
2	54.8	21.0	7.25	2.26		1.67	3.06	6.47	11.9	19.6	29.0	40.8	55.8	78.5	95.1	119	155	187	231	269	307	2
2½	102	39.4	13.6	4.23	1.87		1.83	3.87	7.12	11.7	17.4	24.4	33.4	47.0	56.9	71.5	92.6	112	138	161	184	2½
3	170	65.4	22.6	7.03	3.11	1.66		2.12	3.89	6.39	9.48	13.3	20.9	23.7	31.2	39.1	50.6	61.1	75.5	88.0	100	3
4	376	144	49.8	15.5	6.87	3.67	2.21		1.84	3.02	4.48	6.30	8.61	12.1	14.7	18.5	23.9	28.9	35.7	41.6	47.4	4
5	686	263	90.9	28.3	12.5	6.70	4.03	1.83		1.65	2.44	3.43	4.69	6.60	8.00	10.0	13.0	15.7	19.4	22.6	25.8	5
6	1,116	429	148	46.0	20.4	10.9	6.56	2.97	1.63		1.48	2.09	2.85	4.02	4.86	6.11	7.91	9.56	11.8	13.8	15.6	6
7	1,707	656	226	70.5	31.2	16.6	10.0	4.54	2.49	1.51		1.41	1.93	2.71	3.28	4.12	5.34	6.45	7.97	9.31	10.6	7
8	2,435	936	322	101	44.5	23.8	14.3	6.48	3.54	2.18	1.43		1.35	1.93	2.33	2.92	3.79	4.57	5.67	6.60	7.52	8
9	3,335	1,281	440	137	60.8	32.5	19.5	8.85	4.85	2.98	1.95	1.37		1.41	1.71	2.14	2.77	3.35	4.14	4.83	5.50	9
10	4,393	1,688	582	181	80.4	42.9	25.8	11.7	6.40	3.93	2.57	1.80	1.32		1.21	1.52	1.97	2.38	2.94	3.43	3.91	10
11	5,642	2,168	747	233	103	55.1	33.1	15.0	8.22	5.05	3.31	2.32	1.70	1.28		1.26	1.63	1.88	2.43	2.83	3.22	11
12	7,087	2,723	938	293	129	69.2	41.6	18.8	10.3	6.34	4.15	2.91	2.13	1.61	1.26		1.30	1.57	1.93	2.26	2.58	12
13	8,657	3,326	1,146	358	158	84.5	50.7	23.0	12.6	7.75	5.07	3.56	2.60	1.98	1.53	1.22		1.21	1.49	1.74	1.98	13
14	10,600	4,070	1,403	438	193	103	62.2	28.2	15.4	9.48	6.21	4.35	3.18	2.41	1.88	1.50	1.22		1.24	1.44	1.64	14
15	12,824	4,927	1,698	530	234	125	75.3	34.1	18.7	11.5	7.52	5.27	3.85	2.92	2.27	1.81	1.48	1.21		1.17	1.35	15
16	14,978	5,758	1,984	619	274	146	88.0	39.9	21.8	13.4	8.78	6.15	4.51	3.41	2.66	2.12	1.73	1.42	1.18		1.14	16
17	17,537	6,738	2,322	724	320	171	103	46.6	25.6	15.7	10.3	7.20	5.27	3.99	3.11	2.47	2.03	1.66	1.37	1.17		17
18	20,327	7,810	2,691	840	371	198	119	54.1	29.6	18.2	11.9	8.35	6.11	4.63	3.60	2.87	2.35	1.92	1.59	1.36	1.16	18
20	26,676	10,249	3,532	1,102	487	260	157	70.9	38.9	23.9	15.6	10.9	8.02	6.07	4.73	3.76	3.08	2.52	2.08	1.78	1.52	20
24	42,624	16,376	5,644	1,761	778	416	250	113	62.1	38.2	25.0	17.5	12.8	9.70	7.55	6.01	4.92	4.02	3.32	2.84	2.43	24
30	75,453	28,990	9,990	3,117	1,378	736	443	201	110	67.6	44.2	31.0	22.7	17.2	13.4	10.7	8.72	7.14	5.88	5.03	4.30	30
36	120,100	46,143	15,902	4,961	2,193	1,172	705	319	175	108	70.4	49.3	36.1	27.3	21.3	16.9	13.9	11.3	9.37	8.01	6.85	36
42	177,724	68,282	23,531	7,341	3,245	1,734	1,044	473	259	159	104	73.0	53.4	40.5	31.5	25.1	20.5	16.8	13.9	11.9	10.1	42
48	249,351	95,818	33,020	10,301	4,554	2,434	1,465	663	363	223	146	102	75.0	56.8	44.2	35.2	28.8	23.5	19.4	16.6	14.2	48

THE BIGELOW COMPANY, NEW HAVEN, CONNECTICUT

BLACK OR GALVANIZED STANDARD WEIGHT PIPE

DIAMETER			Thickness	CIRCUMFERENCE		TRANSVERSE AREAS			Nom. Weight per Foot, lbs.	Threads per Inch
Nom.	External	Internal		External	Internal	External	Internal	Metal		
1/8	.405	.269	.068	1.272	.845	.1288	.0568	.0720	.241	27
1/4	.540	.364	.088	1.696	1.144	.2290	.1041	.1249	.42	18
3/8	.675	.493	.091	2.121	1.549	.3578	.1909	.1669	.559	18
1/2	.840	.622	.109	2.639	1.954	.5542	.3039	.2503	.837	14
3/4	1.050	.824	.113	3.299	2.589	.8659	.5333	.3326	1.115	14
1	1.315	1.047	.134	4.131	3.289	1.3581	.8609	.4972	1.668	11 1/2
1 1/4	1.660	1.380	.140	5.215	4.335	2.1642	1.4957	.6685	2.244	11 1/2
1 1/2	1.900	1.610	.145	5.969	5.058	2.8353	2.0358	.7995	2.678	11 1/2
2	2.375	2.067	.154	7.461	6.494	4.4301	3.3556	1.074	3.609	11 1/2
2 1/2	2.875	2.467	.204	9.032	7.750	6.4918	4.7800	1.712	5.739	8
3	3.500	3.066	.217	10.996	9.632	9.6211	7.3827	2.238	7.536	8
3 1/2	4.000	3.548	.226	12.566	11.146	12.566	9.886	2.680	9.001	8
4	4.500	4.026	.237	14.137	12.648	15.904	12.730	3.174	10.665	8
4 1/2	5.000	4.508	.246	15.708	14.162	19.635	15.960	3.675	12.34	8
5	5.563	5.045	.259	17.477	15.849	24.306	19.985	4.321	14.502	8
6	6.625	6.065	.280	20.813	19.054	34.472	28.886	5.586	18.762	8
7	7.625	7.023	.301	23.955	22.063	45.664	38.743	6.921	23.271	8
8	8.625	7.981	.322	27.096	25.073	58.426	50.021	8.405	28.177	8
9	9.625	8.937	.344	30.238	28.076	72.760	62.722	10.04	33.701	8
10	10.750	10.018	.366	33.772	31.472	90.763	78.822	11.94	40.065	8
11	11.750	11.000	.375	36.913	34.558	108.43	95.034	13.40	45.95	8
12	12.750	12.000	.375	40.055	37.699	127.68	113.09	14.59	48.985	8

DECIMALS OF AN INCH AND FOOT FOR EACH 1/64

Fraction	1/32	1/64	Decimals of an Inch	Decimals of a Foot	Fraction	1/32	1/64	Decimals of an Inch	Decimals of a Foot	Fraction	1/32	1/64	Decimals of an Inch	Decimals of a Foot
1/16	1	1	.015625	.0013	3/8	23		.359375	.0299	11/16	23		.687500	.0573
			.031250	.0026				.375000	.0313			45	.703125	.0586
		3	.046875	.0039			25	.390625	.0326			47	.734375	.0612
			.062500	.0052			27	.421875	.0352			49	.750000	.0625
1/8	3	5	.078125	.0065	7/16	29		.437500	.0365	3/4	25		.765625	.0638
			.093750	.0078				.453125	.0378			51	.781250	.0651
		7	.109375	.0091			15	.468750	.0391			53	.796875	.0664
			.125000	.0104			31	.484375	.0404			55	.812500	.0677
3/16	5	9	.140625	.0117	1/2	33		.490625	.0417	13/16	27		.828125	.0690
			.156250	.0130				.500000	.0430			57	.843750	.0703
		11	.171875	.0143			17	.515625	.0443			59	.859375	.0716
			.187500	.0156			35	.531250	.0456			61	.875000	.0729
1/4	7	13	.203125	.0169	9/16	37		.546875	.0469	7/8	29		.890625	.0742
			.218750	.0182				.562500	.0482			63	.906250	.0755
		15	.234375	.0195			19	.578125	.0495			65	.921875	.0768
			.250000	.0208			39	.593750	.0508			67	.937500	.0781
5/16	9	17	.265625	.0221	5/8	41		.609375	.0521	15/16	31		.953125	.0794
			.281250	.0234				.625000	.0534			69	.968750	.0807
		19	.296875	.0247			21	.640625	.0547			71	.984375	.0820
			.312500	.0260			43	.656250	.0560			73	.990625	.0833
	11	21	.328125	.0273				.671875	.0573				1.000000	.0846
			.343750	.0286										

DECIMALS OF A FOOT FOR EACH INCH

In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.
1	.0833	3	.2500	5	.4167	7	.5833	9	.7500	11	.9167
2	.1667	4	.3333	6	.5000	8	.6667	10	.8333	12	1.0000

Boiler Feed Water

Water is the greatest of known solvents, and in its passage through the soil and over rocks it dissolves various mineral substances. Pure water is unknown in nature, and if it could be obtained it would not be suited for boiler purposes because it would be extremely corrosive. Water containing less than two grains of solid matter per gallon is likely to be corrosive on account of its purity. Rain falling through the air dissolves various substances, such as carbonic acid, sulphuric acid, nitrogen and oxygen. On account of the greater solubility of oxygen, the proportion of this gas dissolved from the air is greater than the nitrogen. When water is heated the gases are expelled and the free oxygen attacks the metal with which it comes in contact unless there is a sufficient current of water to sweep the gas bubbles from off the surface of the metal. This explains the rapid corrosion noted in boilers and other vessels where the water contained is only kept warm.

The most common scale-forming minerals contained in feed water are the carbonate of lime and magnesia and the sulphate of lime. The lime sulphate is particularly detrimental, because it forms an exceedingly hard and impervious scale that adheres tenaciously to the metal surfaces of the boiler. The scale formed by the carbonate of lime is generally easier to remove and is usually of a fairly porous nature.

Magnesia scale, unless combined with other substances, is usually very light and porous and does not offer much resistance to the passage of heat; it is generally not difficult to remove.

The statement is often made that boiler efficiency varies in a fixed proportion to the scale thickness. Such a statement, of course, cannot be true, because density is as important a factor as regards the effect of scale on economy as thickness. Any considerable amount of scale in a boiler is detrimental to economy; but it should be removed in any event, whether the saving of fuel is an object or not, in order to prevent the possibility of the boiler being damaged or exploded by overheating. It is out of place here to attempt to describe the best treatment for the various feed waters found.

When scale is formed in sufficient quantities to make the treatment of the feed water desirable, an analysis should be made of the water and the proper treatment prescribed by an expert.

The following may be considered a rough guide to feed water quality.

The amount of solid matter in the best feed water, which is found very generally in the New England states, is from two to six grains per gallon; with less than two grains of solids per gallon, corrosion is likely to take place.

A good feed water, of which Lake Erie water is typical, contains about nine grains of solids per gallon.

Fair boiler water, as represented by the well waters of the Central States, carries about fifteen grains of solids per gallon. It is usually more economical to use a water of this class than to purchase a better supply from a waterworks system at the usual rates.

Poor feed water contains from fifteen to thirty grains of solids per gallon, and can be used only with the greatest difficulty, if absolutely necessary.

Water containing a greater proportion of solid matter can be considered practically useless for boiler purposes unless it can be treated for the removal of the scale-making matter before it is placed in the boiler.

In locating a new plant, where two or more sources of water supply are available, analysis should be made of the different waters before selecting the water to be used.

Rules for the Running and Care of Steam Boilers

1. The water should show in the gauge glass between the second and third gauge cocks; never let it get below the bottom gauge cock or above the top gauge cock.

2. Pressure should be run up at least once a week so the safety valve will blow off. Should the steam gauge not correspond with the pressure that safety valve is supposed to blow at, both should be inspected and repaired so that they will correspond.

3. Before unbanking the fire, see that the water is at proper height in the gauge glass.

4. In starting up a boiler, never light the fire until the water is at the proper height in the gauge glass.

5. The water column, water gauge, gauge cocks, and water column piping should be thoroughly inspected at intervals and kept perfectly clean.

6. The blow-off cock should be opened every morning before unbanking the fire.

7. The inside of the boiler should be thoroughly cleaned at intervals, so that no excessive amount of scale or sediment is allowed to form.

8. The tubes of the boiler should be kept free from soot.

9. Oil or grease in any form should not be allowed to enter the boiler.

10. Should water not show in the gauge glass at any time the fire should be immediately banked with ashes or fresh coal. Steam outlets should be left as they are, and the feed water should not be turned into the boiler until all trouble is found and the boiler allowed to sufficiently cool.

11. Should the boiler be laid up and be idle for any length of time, it should be thoroughly cleaned both externally and internally; all openings such as handholes, manholes, etc., should be left open for free circulation of air, and under no circumstances should a boiler be laid up with water in it.

12. On starting up a new boiler, it should be thoroughly cleaned by washing, and often it is a good idea to dissolve fifty or sixty pounds of soda ash for each 100 H.P. and pump this into the boiler when first filled, and then start a slow fire for a day or two; then empty the boiler, and remove all manhole and handhole plates, and thoroughly wash the boiler with a strong stream of water.

Useful Information

The circumference of a circle equals 3.1416 multiplied by the diameter.

The area of a circle equals .7854 multiplied by the square of the diameter.

The diameter of a circle multiplied by .8862 is equal to side of an equal square.

Doubling the diameter of a circle increases its area four times.

The side of a square multiplied by 1.128 is equal to the diameter of a circle of equal area.

The surface of a sphere is equal to the square of the diameter multiplied by 3.1416.

The area of a triangle is equal to base multiplied by one half the altitude.

The area of a sector of a circle is equal to one-half the length of the arc multiplied by the radius of the circle.

One cubic foot of water contains $7\frac{1}{2}$ gallons and weighs $62\frac{1}{2}$ pounds.

The capacity of a cylindrical tank is equal to the square of the diameter in inches multiplied by .0034 multiplied by the length.

The safe working pressure of a boiler is the tensile strength multiplied by the thickness of the plate in inches multiplied by the efficiency of the joint, divided by the radius of the boiler multiplied by the factor of safety. That is,

$$\frac{TS \times t \times \%}{R \times FS} = \text{W.P.}$$

The pressure in pounds per square inch of a column of water is equal to the height in feet multiplied by .434.

The area of an ellipse is equal to the major axis multiplied by the minor axis multiplied by .7854.

The area of a segment is equal to its height squared multiplied by 4 and divided by 3 into the square root of twice the radius divided by its height minus .608. That is,

$$\frac{4 H^2}{3} \sqrt{\frac{2 R}{H} - .608}.$$

The tensile strength, as the ultimate strength, means the number of pounds per square inch necessary to pull apart a section.

Elastic limit as yield point is where the applied strength begins to produce a permanent elongation.

Elongation means percentage of stretch in a given length, generally 8''.

Reduction of area is just opposite to elongation.

The safe working pressure for finding the resistance of cylinders of steel against collapsing is 89600 multiplied by thickness of material squared in decimals divided by the length of the cylinder in feet multiplied by the internal diameter of the cylinder in inches. That is,

$$\frac{89600 \times T^2}{L \times D} = \text{safe W.P.}$$

T equals thickness of material in decimals of an inch.

L equals length of cylinder in feet.

D equals internal diameter of cylinder in inches.

The indicated horse-power of a single-cylinder steam engine is the pressure in pounds multiplied by the length of stroke in feet multiplied by the area of the piston in square inches multiplied by the number of strokes per minute (that is twice the number of revolutions), divided by 33000.

$$\text{That is, I.H.P.} = \frac{PLAN}{33000}.$$

CONTENTS

	PAGE		PAGE
HORIZONTAL RETURN TUBULAR BOILERS	6-13	PLATE 30 — VARIOUS LAP AND BUTT TYPE JOINTS	26
Simplicity — Erection and Setting — Direct Heating Surface		SETTING PLAN OF HORIZONTAL RETURN TUBULAR BOILER SET WITH	
Easy Cleaning — Large Liberating Surface — Circulation		OVERHANGING FRONT AND BOILER SET ON BRACKETS	28
Repairs — Riveted Joints — Nozzles — Hanger Pads and		SETTING PLAN OF HORIZONTAL RETURN TUBULAR BOILER WITH FLUSH	
Brackets — Manhole — Re-enforcements — Feed Con-		FRONT AND BOILER SET ON BRACKETS	30
nection — Fronts — Binder Bars — Arch Bars — Linings for		SETTING PLAN OF HORIZONTAL RETURN TUBULAR BOILER WITH OVER-	
Fire-Door Openings — Cleanout Doors — Grates — Water		HANGING FRONT AND BOILER SUSPENDED FROM I BEAMS RESTING	
Column — Safety Valves and Steam Gauges — Specifications.		ON COLUMNS	32
SETTING HORIZONTAL RETURN TUBULAR BOILERS	14-20	SETTING PLAN OF HORIZONTAL RETURN TUBULAR BOILER WITH FLUSH	
Foundations — Unloading — Placing the Boiler in Position		FRONT AND BOILER SUSPENDED FROM I BEAMS AND RESTING ON	
— Temporary Support — Materials Required — Design of		COLUMNS	32
Setting Walls — Bridge Wall — Combustion Chamber —		SECTION OF ONE HORIZONTAL RETURN TUBULAR BOILER SUSPENDED	
Fire-brick Lining — Binder Bars — Allowance for Expansion		FROM I BEAMS RESTING ON COLUMNS	33
Boilers Supported on Columns — Covering the Top of the		SECTION OF TWO HORIZONTAL RETURN TUBULAR BOILERS SUSPENDED	
Boiler — Setting Water Columns — Starting Boilers —		FROM I BEAMS RESTING ON OUTSIDE COLUMNS	33
Laying up a Boiler	36	SECTION OF THREE HORIZONTAL RETURN TUBULAR BOILERS SUSPENDED	
COMPONENT PARTS IN PRESSED STEEL	36	FROM I BEAMS RESTING ON OUTSIDE COLUMNS	33
GRATES	36	SECTION OF FOUR HORIZONTAL RETURN TUBULAR BOILERS SUSPENDED	
MANNING BOILER	37-40	FROM I BEAMS RESTING ON OUTSIDE AND CENTER COLUMNS	34
Strength of Boiler — Base — Plates — Reverse Flange —		SECTION OF SIX HORIZONTAL RETURN TUBULAR BOILERS SUSPENDED	
Cleaning Device — Tubes — Outside Furnace — Construc-		FROM I BEAMS RESTING ON OUTSIDE AND CENTER COLUMNS	34
tion of Outside Furnace — Furnaces — Operative Features —		PLATE 31 — STEAM DOME CONSTRUCTION	36
Radiation — Superheat — Space	41	PLATE 32 — VARIOUS PRESSED STEEL PARTS AS USED ON OUR	
DOOR CONSTRUCTION ON MANNING BOILERS	41	HORIZONTAL RETURN TUBULAR BOILERS	36
Flanging		PLATE 33 — THREE TYPES OF STATIONARY GRATES	36
INSTRUCTIONS FOR SETTING BIGELOW MANNING AND STRAIGHT		PLATE 34 — GENERAL CONSTRUCTION OF MANNING BOILER SET ON	
SHELL VERTICAL BOILERS	43-44	INDEPENDENT CAST-IRON BASE	39
Unloading — Setting the Base — Fire Doors and Frames —		PLATE 35 — GENERAL CONSTRUCTION OF LARGE STRAIGHT SHELL UP-	
Smoke Bonnet — Location of Water Column — Cleaning		RIGHT BOILER SET ON FLAT BASE	39
Out and Starting Boilers — Laying up Boilers	49	PLATE 36 — SECTION OF PLATE JUST ABOVE THE FEED, SHOWING TUBE	
LOCOMOTIVE BOILERS	49	LAYOUT AND CLEANING DEVICE	39
Mounting — Dome	50	PLATE 37 — INDEPENDENT CAST-IRON BASE SUCH AS CAN BE USED ON	
SMALL UPRIGHT BOILERS	50	EITHER THE MANNING OR LARGE STRAIGHT SHELL UPRIGHT BOILER	
INTERNALLY FIRED BOILERS OF THE CONTINENTAL TYPE	52-53	PLATE 38 — FIRE DOOR AS USED ON MANNING AND LARGE STRAIGHT	
Horse-power — Efficiency — Construction	54-55	SHELL UPRIGHT BOILERS	40
SMOKE FLUES	54-55	PLATE 39 — METHOD OF FLANGING THE FIRE DOOR OPENING IN	
Round Flues — Rectangular Flues — Flue Areas Required	56-57	MANNING AND LARGE STRAIGHT SHELL UPRIGHT BOILERS	41
STACKS	56-57	PLATE 40 — INSIDE FURNACE SHEET JUST AFTER THE DOOR OPENING	
Self-Sustaining Stacks — Guyed Stacks	58	HAS BEEN FLANGED	41
DEVULCANIZERS	58	PLATE 41 — PARTIAL BATTERY OF ELEVEN 225 HORSE-POWER MANNING	
The Principle — The Construction — Ring and Cover Bolts		BOILERS INSTALLED AT THE PLANT OF LANDERS, FRARY & CLARK,	
— Track and Carriage	59	NEW BRITAIN, CONN.	42
THE HOGEL DRYER	59	PLATE 42 — PARTIAL BATTERY OF SIXTEEN 500 HORSE-POWER	
DIGESTERS AND LARD COOLERS	60	MANNING BOILERS IN THE COURSE OF ERECTION AT ARLINGTON	
PRESSURE TANKS AND BLEACHING KIERS	61	MILLS, LAWRENCE, MASS., UNDER WHICH ARE INSTALLED EIGHT	
CUPOLAS	62	RONEY TYPE OF STOKERS AND EIGHT TAYLOR TYPE OF STOKERS	44
BOILER FEED WATER	69	PLATE 43 — THREE 260 HORSE-POWER MANNING BOILERS SET WITH	
RULES FOR THE RUNNING AND CARE OF STEAM BOILERS	70	MURPHY STOKERS AT THE BRIDGEPORT MALLEABLE IRON CO.,	
USEFUL INFORMATION	71	BRIDGEPORT, CONN.	45

ILLUSTRATIONS

WORKS OF THE BIGELOW CO., NEW HAVEN, CONN., U.S.A.	2	PLATE 44 — LOCOMOTIVE TYPE OF BOILER MOUNTED ON SKIDS	49
PLATE 1 — HORIZONTAL RETURN TUBULAR BOILER SET WITH OVER-		PLATES 45, 46, 47 — SMALL UPRIGHT BOILERS	50
HANGING CAST-IRON FRONT	7	PLATE 48 — INTERNALLY FIRED BOILER OF CONTINENTAL TYPE	52
PLATE 2 — HORIZONTAL RETURN TUBULAR BOILER SET WITH OVER-		PLATE 49 — ROUND TYPE OF SMOKE FLUE IN CONNECTION WITH TWO	
HANGING PLATE STEEL FRONT	8	HORIZONTAL RETURN TUBULAR BOILERS	54
PLATE 3 — HORIZONTAL RETURN TUBULAR BOILER SUSPENDED FROM		PLATE 50 — SECTION OF RECTANGULAR SMOKE FLUE SHOWING CON-	
I BEAMS RESTING ON COLUMNS, WITH OVERHANGING PLATE STEEL		STRUCTION	54
FRONT	9	PLATE 51 — RECTANGULAR TYPE OF SMOKE FLUE IN CONNECTION	
PLATE 4 — HORIZONTAL RETURN TUBULAR BOILER SET WITH DUTCH		WITH TWO HORIZONTAL RETURN TUBULAR BOILERS	55
OVEN AND PLATE STEEL FRONT	9	PLATE 52 — THE GENERAL CONSTRUCTION OF SELF-SUSTAINING STACK	
PLATE 5 — HORIZONTAL RETURN TUBULAR BOILER SET WITH PLATE		AND ARRANGEMENT OF BASE AND ANCHOR BOLTS, ATTACHMENT OF	
STEEL FLUSH FRONT	10	THE LUGS ON THE CONE; ALSO RE-ENFORCEMENT OF THE SMOKE-	
PLATE 6 — CAST-IRON REMOVABLE TYPE OF ARCH AND JAMB	10	FLUE OPENING	56
PLATE 7 — HORIZONTAL RETURN TUBULAR BOILER SET WITH CAST-		PLATE 53 — GUYED STACK WITH ARRANGEMENT OF BASE WE RECOM-	
IRON FLUSH FRONT	11	MEND AND RE-ENFORCEMENT OF FLUE OPENING	56
PLATE 8 — FIRE-BRICK ARCH AND JAMB	11	PLATE 54 — VULCANIZER WITH DOOR OPEN	58
PLATE 9 — BATTERY OF HORIZONTAL RETURN TUBULAR BOILERS WITH		PLATE 55 — CROSS SECTION OF RING USED ON VULCANIZERS	58
OVERHANGING FRONTS, INSTALLED AT THE PACIFIC MILLS, LAW-		PLATE 56 — THE HOGEL DRYER WITH SHELL CUT AWAY, SHOWING	
RENCE, MASS.	12	ARRANGEMENT OF REAL INSIDE OF DRYER	59
PLATE 10 — BATTERY OF HORIZONTAL RETURN TUBULAR BOILERS		PLATE 57 — STANDARD LARD COOLER	60
WITH FLUSH FRONTS	13	PLATE 58 — STANDARD DIGESTER	60
PLATE 11 — OVERHANGING CAST-IRON FRONT WITH SINGLE FIRE DOOR		PLATE 59 — PRESSURE TANK	61
OPENING AND FULL FLUE DOORS	14	PLATE 60 — BLEACHING KIER	61
PLATE 12 — OVERHANGING PLATE STEEL FRONT WITH TWO FIRE DOOR		PLATE 61 — GENERAL VIEW OF STANDARD CUPOLA	62
OPENINGS AND FULL FLUE DOORS	14		
PLATE 13 — OVERHANGING PLATE STEEL FRONT WITH TWO FIRE DOOR			
OPENINGS AND HALF FLUE DOORS	14		
PLATE 14 — BACK OF PLATE STEEL OVERHANGING FRONT WITH THE			
ARRANGEMENT OF ARCH AND JAMB IN PLACE AND REMOVED	15		
PLATE 15 — CAST-IRON FLUSH FRONT WITH SINGLE FIRE DOOR OPENING.			
PLATE 16 — PLATE STEEL FLUSH FRONT WITH TWO FIRE DOOR OPENINGS.			
PLATE 17 — HORIZONTAL RETURN TUBULAR BOILER MADE IN TWO			
COURSES WITH TRIPLE RIVETED BUTT JOINT AND TWO PRESSED			
STEEL BRACKETS ON EACH SIDE	16		
PLATE 18 — FLUSH FRONT RISER CASTING FOR CONNECTING FLUE			
UPTAKE	16		
PLATE 19 — HORIZONTAL RETURN TUBULAR BOILER MADE IN THREE			
COURSES WITH QUADRUPLE RIVETED JOINT AND FOUR PRESSED			
STEEL BRACKETS ON EACH SIDE	17		
PLATE 20 — OVERHANGING FRONT RISER CASTING FOR CONNECTING			
FLUE UPTAKE	17		
PLATE 21 — STANDARD CLEAN-OUT DOOR AND FRAME WITH CAM DOOR			
FASTENER	17		
PLATE 22 — HORIZONTAL RETURN TUBULAR BOILER MADE IN TWO			
COURSES, QUADRUPLE RIVETED JOINT AND FOUR PRESSED STEEL			
BRACKETS ON EACH SIDE	18		
PLATE 23 — CAST-IRON WATER COLUMN	18		
PLATE 24 — HORIZONTAL RETURN TUBULAR BOILER MADE IN THREE			
COURSES WITH QUADRUPLE RIVETED JOINT AND PRESSED STEEL			
HANGER PADS	19		
PLATE 25 — CAST-IRON REAR ARCH TEE BAR	19		
PLATE 26 — REAR HEAD CONSTRUCTION AND ARRANGEMENT OF BRACING			
OF A HORIZONTAL RETURN TUBULAR BOILER SEEN FROM THE			
INSIDE OF THE BOILER	20		
PLATE 27 — LONGITUDINAL SECTION OF HORIZONTAL RETURN			
TUBULAR BOILER AND ARRANGEMENT OF BRACING	20		
PLATE 28 — FRONT VIEW OF HORIZONTAL RETURN TUBULAR BOILER			
WITH HANDHOLE BELOW THE TUBES	20		
PLATE 29 — FRONT VIEW OF HORIZONTAL RETURN TUBULAR BOILER			
WITH MANHOLE BELOW THE TUBES	20		
DIAMETERS OF BOILERS AND NUMBER AND DIAMETERS OF TUBES	22-23		

TABLES

HORSE-POWER RATING OF HORIZONTAL RETURN TUBULAR BOILERS	21
DATA ON BRACING HORIZONTAL RETURN TUBULAR BOILERS FOR	
100, 125 AND 150 LBS. PRESSURE	24
TEST OF BOILERS AT THE MAIN PLANT OF THE BRIDGEPORT BRASS CO.	25
SINGLE RIVETED LAP JOINTS	26
DOUBLE RIVETED LAP JOINTS	26
TRIPLE RIVETED LAP JOINTS	26
DOUBLE RIVETED BUTT STRAP JOINTS	27
TRIPLE RIVETED BUTT STRAP JOINTS	27
QUADRUPLE RIVETED BUTT STRAP JOINTS	27
MEASUREMENTS FOR SETTING HORIZONTAL RETURN TUBULAR BOILERS	
WITH OVERHANGING FRONTS	29
MEASUREMENTS FOR SETTING HORIZONTAL RETURN TUBULAR BOILERS	
WITH FULL FLUSH FRONTS	31
MEASUREMENTS FOR SETTING HORIZONTAL RETURN TUBULAR BOILERS	
SUSPENDED FROM STRUCTURAL WORK	35
GENERAL DIMENSIONS OF MANNING AND LARGE UPRIGHT BOILERS	47
PERFORMANCE OF BATTERY OF BIGELOW CO.'S MANNING BOILERS AT	
BRISTOL MFG. CORPORATION, NEW BEDFORD, MASS.	48
PERFORMANCE OF SINGLE MANNING BOILERS, NO. 1 OF BATTERY OF	
NINE, AT BRISTOL MFG. CORPORATION, NEW BEDFORD, MASS.	48
SPECIFICATIONS FOR LOCOMOTIVE BOILERS	49
SPECIFICATIONS OF REGULAR UPRIGHT BOILERS	51
SPECIFICATIONS OF SUBMERGED HEAD UPRIGHT BOILERS	51
KENT'S TABLE ON SIZES OF CHIMNEYS FOR STEAM BOILER	
SUPERHEATED STEAM	57
SATURATED STEAM PRESSURE	63
POUNDS OF WATER EVAPORATED FROM AND AT 212° F.	64
CYLINDRICAL VESSELS, TANKS, CISTERNS, ETC.	65
NUMBER OF U.S. GALLONS IN RECTANGULAR TANKS	66
STANDARD BOILER TUBES	67
EQUATION OF PIPES — STANDARD STEAM AND GAS PIPES	67
BLACK OR GALVANIZED STANDARD WEIGHT PIPE	68
DECIMALS OF AN INCH AND FOOT FOR EACH 1/4	68
DECIMALS OF A FOOT FOR EACH INCH	68

